POWER

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The Perpetuum Mobile

JAMES WATT, in his application for a patent for his engine, said: "I have what every subject of Your Majesty desires—power."

That power, which Watt produced from fuel, has turned out to be a supreme advantage to man in his unceasing struggle with his environment. It has enabled him to subdue the wilderness, to master the sea and the air, to annihilate time and distance and to raise the standard of his living until the laborer enjoys material and intellectual advantages unknown to the most fortunate of an earlier age.

It is not strange that this power should be an attractive lure for the ungrounded speculator in mechanical possibilities, or an attractive bait for separating the unwary and uninformed investor from his savings.

The search for perpetual motion has been ages long, but there is no better established fact known to man than that no manifestation of energy can be produced except at the expense of an equal amount of energy of the same or another kind.

No combination mechanical, electrical or chemical can be conceived that will continuously deliver more energy than is put into it.

The understanding of simple principles that can be mastered in a few hours' study of a text-book of physics will make this apparent, and yet we are continually called upon to demonstrate the fallacy of perpetual motion schemes the impossibility of which would be obvious to a high-school student.

Most of these devices are based upon some misconception of the advantages of leverage, or the effects of gravity or buoyancy.

Force can be multiplied by leverage, but the smaller force must be exerted through a correspondingly greater distance, and the energy, which is the product of force and distance, will be the same. It takes as much energy to submerge a float as it will yield on rising, just as it takes as much energy to raise a weight, whatever the course it follows in its rise, as it will develop in falling. Electricity has been the subject of less of these fallacious attempts than might have been expected, probably for the reason that those who knew enough about electricity to have been led into them knew enough about it to be kept out.

There have been a few of these "inventors" who have reached out into the great unknown for their source of energy; the immortal Keely and Garabed Giragossian for example. The recent mutterings of science about the amount of energy locked up in atomic systems is likely to lead to speculative enterprises upon this basis. It will be pointed out that the transmutation of metals, so long ridiculed byscientists, has been demonstrated to be actually occurring in radio-active substances, and that the physicists may be equally overpositive with regard to the conservation of energy. Dr. F. W. Aston, M. A., F. R. S. in a lecture at the Engineers' Club on the eve of his recent departure for England, said that if as much hydrogen as is contained in 9 cubic centimeters of water were converted into helium, 200,000 kilowatt-hours of energy would be generated. But if any power is derived from breaking up the minute planetary systems of the atom it will be at the expense of energy already there and not through the production of energy *de novo* and, as Dr. Aston warned, he who discovers the process may set off a train of decomposition which will cause the record of his achievement to be written on the firmament in a new star.

There seems to be an epidemic of perpetual motions at present. One which is being vigorously exploited through circulars and other advertising is shown on another page of this issue. Their projectors may be honest, but they are not right. Unfortunately, it is of little use for us to warn our readers against investing in them, for to the engineer the absurdity of their claims is already apparent.

The daily press should be exposing instead of advertising such pitfalls for the investor, and the Post Office Department should deny the use of the mails to the circulation of this kind of solicitation. A purchaser of a lottery ticket has some chance—long though it may be — but the purchaser of shares in one of these perpetual motion schemes has no chance whatever.

F. R. Low

Solving the Feed-Water Problem at New Orleans

By O. P. ADAMS* and PAUL F. HOOTS†
New Orleans Railway and Light Co.

THE 50,000-kw. plant of the New Orleans Railway and Light Co. uses Mississippi River water for makeup with practically no trouble from scale or priming, although the boilers operate at high rating. This is accomplished by lime-soda-copperas treatment in a steam-heated tank and by using periodic water tests as the basis of correct treatment aud scientific plant operation.

DURING the last two years the increasing load on the Central Power Station of the New Orleans Railway and Light Co. has made it necessary to operate boilers at very high ratings. In the summer of 1921 it became apparent that boiler feed must be maintained at a much lower content of foaming salts and scale-forming material than the existing practice afforded.

The plant carries a load of around 550,000 kw.-hr. per day with an evening peak of about 42,000 kw. The equipment consists, briefly, of fourteen 9,000-sq.ft. Babcock & Wilcox water-tube boilers, six economizers (each connected to a pair of boilers), open heater, feed pumps, fans, etc., two 15,000-kw. horizontal turbo-generators with surface condensers, one 5,000- and one 2,500-kw. vertical turbo-generator with surface condensers, one 3,000- and two 2,500-kw. vertical turbo-generators with barometric condensers, and two vertical compound engines of 1,500- and 2,500-kw. capacity with direct-current generators and barometric condensers.

The condensate from the surface condensers returns directly to the heater, the water level being maintained by a float-operated valve on the makeup feed line. The numerous steam-driven auxiliaries in the plant furnish more exhaust steam than is needed to maintain the feed temperature at its maximum, and consequently part of the exhaust is wasted to atmosphere, while the heater temperature is maintained at about 212 deg. F. continuously. It may be mentioned here that the addition of a new generating unit contemplated for installation in the near future will restore the station heat balance so that it would not be worth while to make any extensive changes in the existing auxiliaries.

The three-stage centrifugal feed pumps take suction directly from the heater. The economizer, being in series between the first and second stages, operates at 100 lb. gage pressure, and the feed water is delivered to the boiler from the third stage at about 235 lb. The plant operates at 200 lb. steam pressure with an average superheat at the throttle of the turbines of 160 deg. F.

Plant Uses Three Kinds of Water

Three different waters are used in the plant: Raw water from the Mississippi River, which is used for condenser circulating water; water from an artesian well, which is used for cooling bearings and transformers and for general plant purposes; and treated water for makeup feed, which is derived from the river water by the continuous lime, soda-ash and copperas (iron sulphate) method. The raw river water is never extremely hard, varying from 4 to 15 grains (calcium-carbonate equivalent) per U. S. gallon, but contains large and widely varying amounts of suspended matter, depending on the season and whether the river is rising or falling. As a rule the hardness of the water and the quantity of suspended matter vary in inverse ratio; that is, when the hardness is low the suspended matter is at a maximum and vice versa. The river is generally low during the winter months, and the hardness high with comparatively small amounts of suspended matter. There are few foaming salts.

The artesian-well water, on the other hand, is extremely soft and contains no suspended matter. The foaming salts in this water are high, however, sodium chloride and free sodium carbonates being present in large quantities, with small amounts of sulphates. The high concentration of foaming salts, especially sodium carbonate, makes this water unfit for boiler-feed.

River Water Is Chemically Treated

The lime, soda-ash and copperas process for producing makeup feed from the raw river water produces the following changes in its characteristics. The hardness is reduced to from 2 to 6 grains per gallon, depending on the temperature and hardness of the raw water, better softening being possible during the summer months. By the use of iron sulphate as a coagulent for sedimentation, the suspended matter is reduced to a quantity that never gives any trouble. The quantity of foaming salts is, however, considerably increased by the treating process. Sodium chloride, and sulphate are added by the reaction between the soda ash and the permanent hardness. Sodium carbonate and hydrate must be added in excess, and the sodium sulphate is also largely increased owing to the chemical reactions between the lime, iron sulphate and sodium carbonate. Impurities in the softening reagents also tend to increase the foaming salts. By maintaining the excess of sodium carbonate and hydrate at the lowest practical figure and using the smallest allowable amount of iron sulphate, the foaming salts are kept at a minimum.

The following analyses will show more clearly the characteristics of the waters used:

	Mississippi River Water	Treated Water	Artesian Well Water
Total hardness, grains per U. S. Gal. as Calcium Carbonate	4.0—15.0	2.0—6.0	3.5
Foaming Salts:			
Sodium chloride, grains per U. S. gal.	1.8	5.6	34.2
Sodium sulphate, grains per U. S. gal.	1.4	6.6	0.2
Sodium carbonate, grains per U. S. gal.	0.0	1.1	20.6
Sodium hydrate, grains per U. S. gal.	0.0	1.1	0.0
Total foaming salts, grains per U. S. gal.	3.2	14.4	55.0
Suspended matter, grains per U. S. gal.	5.0—125.0	1.2	None

In the table minimum and maximum values are given for quantities subject to wide variation. Values for the treated water are taken from analyses made before the installation of heating coils.

The measures decided upon for reducing the percentages of foaming salts and scale-forming ingredients were carried forward simultaneously, but for the sake of clearness will be described separately, beginning

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with the elimination of excessive amounts of foaming salts.

Careful analyses of the hotwell returns and a sample condensed from the steam line indicated that an excessive amount of well water was getting into the feed system from various sources, chief of which were hotwell-pump sealing glands. These glands were supplied with sealing water from the house circulating system which is supplied from the well. As this water contains about 55.0 grains of various salts that may cause foaming, a relatively small amount of well water in the condensate caused a large increase in boiler-feed concentrations.

There were also a few leaky cross connections between the two water systems. These were either eliminated or provided with two valves with an open bleeder

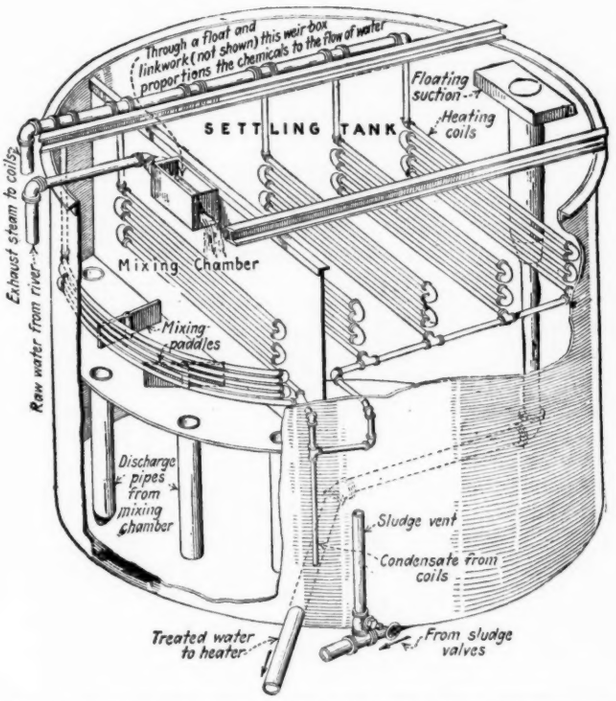
Through a float and linkwork (not shown) this weir-box proportions the chemicals to the flow of water
Floating suction
SETTLING TANK
Heating coils
Exhaust steam to coils
Raw water from river
Mixing Chamber
Mixing paddles
Discharge pipes from mixing chamber
Sludge vent
Condensate from coils
Treated water to heater
From sludge valves

FIG. 1. STEAM-HEATED TANK FOR TREATING MISSISSIPPI RIVER WATER AT NEW ORLEANS

valve between. Water for hotwell pump glands was piped back from the discharge side of the hotwell pump.

After eliminating all possibility of well water getting into the system, the amount of condenser leakage was determined by taking samples of water from the hotwell discharge, the condenser cooling water, and steam condensed from the main steam line to the turbine, and analyzing these samples for chlorine content by the silver-nitrate titration method. This was simple in operation and furnished accurate results.[1]

With accurate data as to condenser leakage at hand, repairs could be carried forward intelligently to reduce this source of trouble. It has been found practicable to keep condenser leakage below 2 per cent.

At the same time that the foregoing changes were being made, experiments were being carried on with an electrical-resistance type of concentration indicator. This instrument consists of a Wheatstone bridge wound with non-inductive resistance for alternating current, a specially constructed set of terminals for immersing in the solution to be tested, and a transformer to deliver 110 volts to the bridge and to insure against the effect of grounds in the external circuit. The use of alternating current prevents polarization at the terminals in the solution. The resistance of the water to be tested decreases with increase in the percentage of soluble salts, and a curve may be constructed, by taking readings on solutions of known strength, that will show the concentration for any given instrument reading. This curve will not give accurate results if the proportions of the salts in solution vary considerably, but a calibration of the instrument against solutions having these salts in the average proportions found in the boiler water will give results close enough for an intelligent control of boiler concentrations. It is of course necessary to adopt a standard solution temperature for both calibration and use, 32 deg. C. (90 deg. F) being used at this plant.

Samples are taken each morning from the drums of the boilers, and the instrument readings noted and posted in the boiler room for the guidance of the boiler-room force in blowing down, changing water, etc. Two hundred grains per gallon of foaming salts is the allowable limit, and boilers showing higher concentrations are blown down heavily, while those showing low concentrations are blown just enough to get rid of scale deposits and mud.

Since this program of changes has been completed, and data supplied daily as to boiler concentrations, it has not been difficult, even during winter load conditions, to keep below the allowable limit of 200 grains per gallon.

Troubles Reduced By Systematic Control

Previous to this time it was practically impossible to keep concentrations down to a reasonable figure during heavy load periods, and although water did not go over in large quantities, there was continuous carrying over of small particles, reducing the superheat and forming in the superheater a white scale whose composition tallied closely with the soluble ingredients and their proportions found in the boiler water. A portion of this scale remained in the superheater, causing some trouble by stoppage and tube failures, but the major portion of it was carried along with the steam and deposited on the walls of the steam lines and in valves and strainers and even on the turbine blading.

No trouble has been experienced from this source since the changes just described were completed. The valves that were inaccessible for cleaning and practically inoperative on account of incrustations of scale are gradually being freed by the scouring action of the clean steam. The actual reduction in foaming ingredients in the boiler feed was from the previous average of 3.7 to the present figure of 1.7 grains per gallon. The importance of these results will be immediately apparent to the operator of an old plant who has been forced by increasing load and high machinery prices to operate boilers at high ratings, unless he is fortunate enough to have an adequate evaporator system and water for condenser cooling having low content of foaming salts.

The problem of reducing the percentage of scale-forming material was important not only from the viewpoint of economy, but also for insuring continuity of service. It has been the experience in this plant that a total hardness of over one grain per gallon in the

[1] This method is fully explained by the authors in an article entitled "A Chemical Method for the Determination of Surface-Condenser Leakage," in the April 4, 1922, issue of "Power."

boiler feed invariably meant the loss of tubes within 24 or 36 hours. Another interesting fact is that these tube losses cease within 24 or 36 hours after the hardness is reduced below that point.

These tube losses which occur in the lower rows of tubes, seem to be independent of the condition of the tube as regards previous scale deposits, it having frequently occurred that a new tube would develop a "bag" in a dirty boiler while adjacent tubes were unaffected. The loss of tubes is incontrovertible proof of decreased boiler efficiency, as a tube failure is caused by the heat-insulating properties of the scale on its surface.

Tests Are Made for Leakage

The problem at this plant involved two phases, the reduction of scale-forming material in the return water from the condensers and an improvement in the method of treating water for makeup. As the leakage of the circulating water into the condensers is the only source of hardness in the hotwell returns, this phase of the problem simply involved an accurate knowledge of the amount of leakage so that repairs could be made intelligently. The method used for obtaining these data has already been described in the discussion of concentration control. A leakage of 2 per cent, which is the allowable high limit, gives the return water a total hardness averaging about 0.16 grain per gallon.

The system in use for treating the raw river water to produce makeup feed is the lime, soda-ash, copperas process, and consists essentially of a combination treating and settling tank 40 ft. in diameter and 25 ft. high. The construction of this plant is clearly shown in Fig. 1. Two small chemical tanks are provided for the mixing and proportioning of the chemicals. The entering water flows over a weir so designed that the quantity is proportional to the head on the weir, and the chemical proportioning gates are actuated by a float that rises and falls with the water in the weir box, so that the amount of chemical solution supplied is always proportional to the quantity of water being pumped into the tank. The chemical tanks are at ground level, so it is necessary to pump the chemicals up to the treating tank. Pumps are also provided for lifting the solution from the chemical tanks to the proportioning box just above them.

The chemical principles involved in the treatment of the water are essentially the same as found in any other lime, soda-ash, copperas system. Lime is added for the purpose of removing the temporary hardness, made up of the bicarbonates of calcium and magnesium, and for the removal of the permanent magnesium hardness, which includes the chlorides and sulphates of magnesium. Any calcium compounds introduced by the reaction between the lime and permanent magnesium hardness are precipitated by the soda ash. The chlorides and sulphates of calcium, originally present as permanent hardness, are also precipitated by the sodium carbonate. Calcium carbonate, the principal product of the softening reactions in this water, is slightly soluble and it is impossible to remove all the hardness. The amount of calcium carbonate soluble in hot water is, however, appreciably less than the quantity soluble in cold water. Not only for this reason, but also because the chemical reactions involved are greatly accelerated in hot water, the advisability of the conversion of the system into a hot process was considered. As the sedimentation of the suspended matter is performed in the same tank as is used for the softening, this slightly complicates the process. Copperas, or iron sulphate, is used for this purpose, depending on the reaction with lime to produce a flocculent precipitate which, in settling out, carries down with it mechanically the suspended matter. The calcium sulphate also produced by the foregoing reaction is precipitated as calcium carbonate by the soda ash. Since the quantity of the chemical solutions pumped into the treating tank is always proportional to the quantity of incoming raw water, it is obvious that any change in the character of the raw water must be taken care of by differences in the concentrations of the treating solutions.

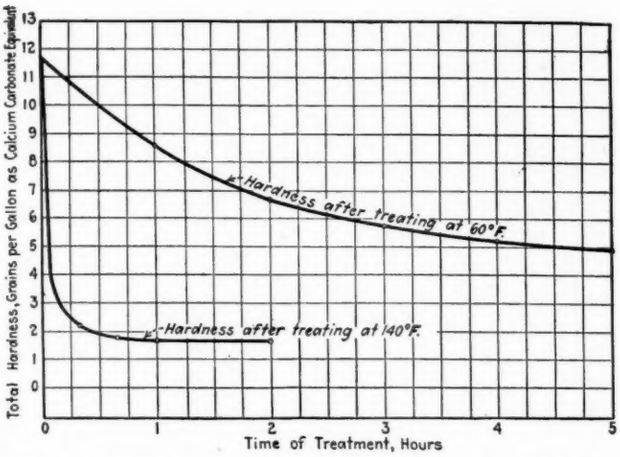

FIG. 2. CURVES SHOWING REMARKABLE SPEEDING UP OF TREATMENT BY INCREASING THE TEMPERATURE

Analyses of the treated water are made twice daily, and the raw water is tested as often as is necessary, usually once each day. The hardness of the waters is determined with a standard soap solution and the alkalinity to phenolphthalein and methyl orange with a standard solution of sulphuric acid. From the results of these tests the quantity of lime and soda-ash to use for correct treatment is determined. The strength of iron-sulphate solution to use is best determined by observation of the clarity of the treated water, while regular analyses of the suspended matter in the raw water furnish valuable information of any extreme changes in the quantity present.

Steam Coils Speed Up Treatment

The chief criticism of the heating idea was the possibility that heating coils in the tank would cause the water to become turbid owing to convection currents. In order to minimize the danger from this source, the coils were hung only six feet below the surface of the water in the tank, an arrangement giving a large dead space below the coils. There are six pipe coils each composed of five 20-ft. lengths of 3-in. pipe. Calculations were made on a basis of being able to maintain a temperature of 140 deg. F. at the surface of the tank during freezing weather with an exhaust-steam pressure of 5 lb. gage at the coils and a consumption of 4,000 lb. of steam per hour. These figures checked very closely with the results obtained except that the radiation from the tank, which is in the open air, was found to be about 9 B.t.u. per sq.ft. per hour per degree difference in temperature, instead of 7 as had been used in making up the original figures.

The results obtained from this arrangement were everything that could be expected. The water was actually lower in suspended matter owing to the reduction in its viscosity, the convection currents' being so slight as to show no appreciable effect. The hardness has been kept at an average of 1.9 grains per gallon (as calcium carbonate) and on some days has gone as low as 1.0 grain.

When the new generating unit is installed and there is no longer an excess of exhaust steam, the temperature of the tank will be reduced to about 120 deg. F. and the expenditure in exhaust steam, after deducting the heat returned to the system by the makeup, will be about 1,500 lb. per hour, or about 0.5 per cent of the steam generated.

Since putting the heating coils into service, we have had very few tube losses, and it is estimated from over-all station results that a saving of from 2 per cent to 3 per cent has been effected through reduction of scale. The expense of cleaning boilers, superheaters and valves has been considerably reduced. Previous to this time there was a considerable deposit of scale on feed-water piping, due, no doubt, to insufficient time for complete reaction of the chemicals in the treating tank. This effect has entirely disappeared as complete chemical reaction takes place in about one-tenth the time required by the cold process.

It is believed that the foregoing methods may be employed by a variety of plants throughout the country, with modifications to suit the conditions, of course, and with equally good results.

The solution of feed-water problems are simplified a hundred-fold by accurate analyses of samples, taken simultaneously, of all waters in use in the plant.

Valves for Large Gas Engines

The means whereby the gas and air are mixed and admitted into the cylinder has an important bearing on the operation of gas engines, especially those of large powers. The old system was to combine a positively

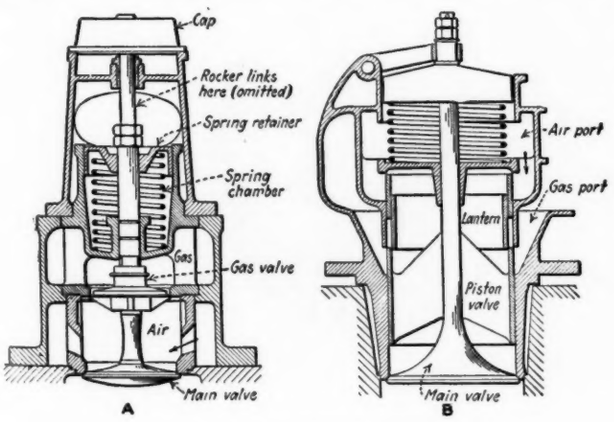

FIG. 1—GAS-INLET VALVE
A, Premier inlet valve. *B*, Cockerill gas and air valve.

operated inlet valve for the mixture with an automatic valve for admitting the air into the gas passage. This never was an efficient method and has been abandoned for valve systems that give closer regulation of the mixture.

A modern arrangement is shown in Fig. 1*A*. Here the valve is double, consisting of a main inlet valve and a gas valve flexibly attached to the same spindle. The valves are opened and closed by a rocker arm, but the final 0.06 in. travel is effected by the spring action.

The amount of gas entering is controlled by the governor, which moves the butterfly valve in both the air

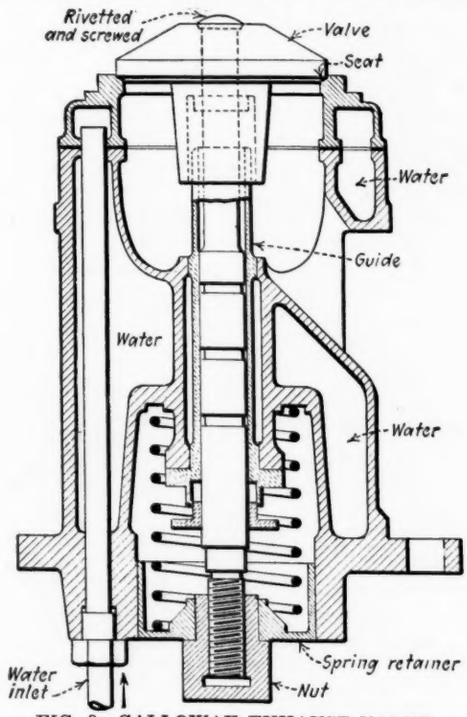

FIG. 2—GALLOWAY EXHAUST VALVE

and the gas lines. This design is used on the Premier (British) gas engine.

The valve shown in Fig. 1*B* is an interesting design as used on the Cockerill (Belgian) engine. It will be seen that there is a piston valve mounted on the stem of the main valve. The duty of this piston valve is to control the gas and air ports, a subsidiary piston or lantern inside it, operated by the governor, controlling the strength of the mixture according to its relative position. This it does by determining the period that the gas port will remain open during the suction stroke independently of the fixed period of opening of the main valve.

With regard to the exhaust valve, cooling of the actual valve is now considered an unwarranted complication, provided the casing and seat are provided with adequate water chambers. This was evident when the new Premier engine was under test, the water provided for circulating in the valve being found unnecessary.

In Fig. 2 is shown the arrangement of exhaust valve found on the latest Galloway engine. It will be seen that the whole valve unit, with its seat, spring and gland, is in a cage having a cooling-water compartment.

It is customary to accelerate turbines or bring them up to the critical speed somewhat faster than the rest of the operations. If there is a bad critical speed with vibration that is objectionable, it is the usual custom to bring the machine to this as quickly as possible. In some exceptional cases, where bad critical speed exists, it is necessary to bring them up in this manner, as otherwise it is hardly possible to bring them through to the steady speed. Bad critical speeds are seldom encountered.

Another Corliss Engine Firm Building Unaflow Engines

THE Murray Iron Works Company, for years known as builders of high-grade Corliss engines, is now engaged in the manufacture of unaflow steam engines. These Murray unaflows will be built in powers ranging from 75 to 650 i.hp., these sizes covering the range of capacities where the unaflow is especially suitable.

The engine is of the side-crank bored guide horizontal design, following somewhat the same lines that are found in the Murray rolling-mill Corliss frame. The cylinder cross-section is shown in Fig. 4, while the steam valve and the auxiliary exhaust valve appear in Fig. 5. The cylinder is designed along the most approved Stumpf unaflow lines. Steam is admitted to each cylinder head through a cast-iron pipe connection. The cylinder heads are steam jacketed, the space forming the steam chest for the engine. In this way the head is kept as hot as the cylinder steam, this being one of the features that reduces condensation losses in the unaflow.

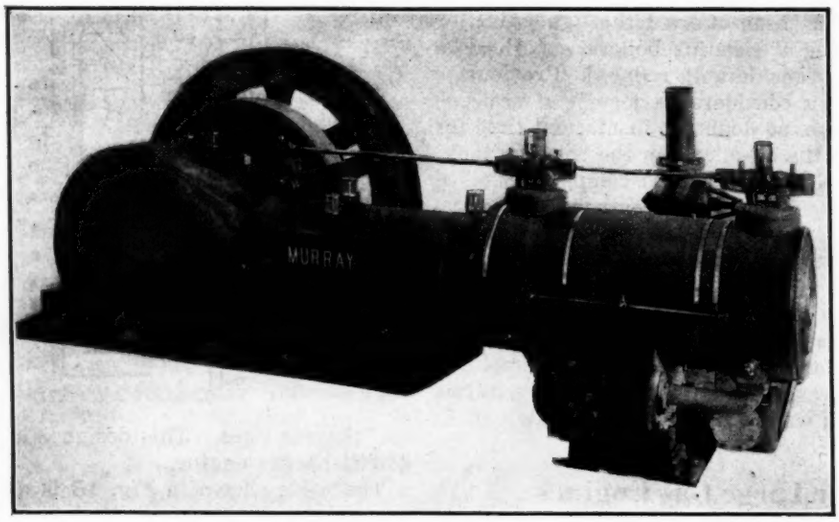

FIG. 1—THE ENGINE IS OF THE SIDE CRANK TYPE

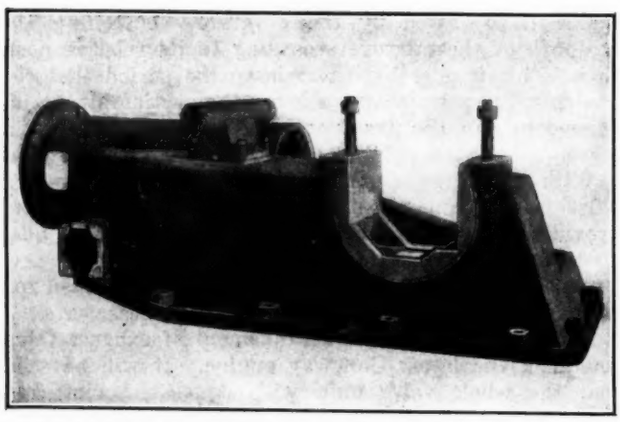

FIG. 2—ENGINE FRAME SHOWING BEARING HOUSING

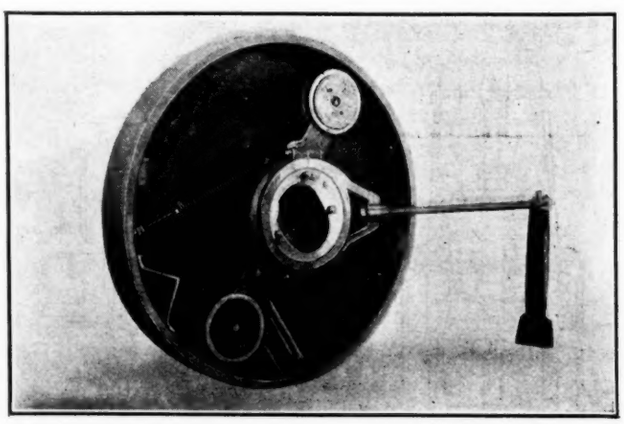

FIG. 3—INERTIA GOVERNOR AND WHEEL

It will be noticed that the cylinder body is not steam jacketed. It has been the common practice of many builders to extend the steam jacketing along the cylinder barrel for some distance. It has been found that the jacketing of the barrel leads to no greater economy and complicates the casting. For this reason the Murray Unaflow has no cylinder jacket, but is lagged with several inches of non-condensing material. This serves to reduce the radiation loss to a minimum.

The exhaust ports are placed in a belt around the center of the cylinder. The port area is many times the valve area of a four-valve engine, thereby eliminating all wiredrawing.

The piston is a one-piece casting and it, as well as the cylinder barrel, is machined at a temperature corresponding to the usual working temperatures.

The steam valve is of the resilient double-beat type. The valve body has formed on it the lower valve seat, while the upper valve seat is a light flexible steel disk held to the valve body by capscrews. By the use of one flexible seat, steam leakage, which often exists when the entire valve is made in one piece, is eliminated. The upper valve disk rests on a seat turned on the head casting, while the lower valve edge rests on a seat that is a separate casting held to the cylinder-head casting by a capscrew. The slight blow given by the valve in closing is absorbed by this lower casting and it may be removed when worn beyond refacing. The steam valve gear is similar to gears long employed on unaflow engines. The governor eccentric drives the valve rod *A*. To the rod are fitted two steel blocks *B* which slide in cavities in each valve bonnet. This block carries a roller contacting with a cam block *D* placed on a crosshead fastened to the valve stem. The re-

ciprocating motion of the valve rod causes the roller *C* to contact with the cam *D*, raising the valve stem and so admitting steam to the cylinder end in question.

The governor is the well-known Rites inertia type and is mounted on a governor pulley, as shown in Fig. 3.

The piston covers the central exhaust ports after approximately 10 per cent of the return stroke is made, and if the clearance is small the compression pressure will rise far above the steam pressure in case of non-condensing operation. The designer must make one of two choices. If the clearance is made large to avoid the excessive pressures, the engine's efficiency will suffer. The alternative is to employ auxiliary exhaust valves which will allow part of the steam in the cylinder to escape after the central ports have been covered. This is the method followed in the Murray engine. The auxiliary valves are of the solid-piston design and are moved by a fixed eccentric through a linkage as shown.

In setting the steam valves, the engine is turned over until the roller *C* is under the flat surface of the cam *B*. The valve stem is then turned until there is a clearance between the cam and roller of 0.002 in. This insures that the valve will be closed when its roller is under the flat surface of the cam.

Adjusting for Lead

To adjust for lead, the first step, if the eccentric rod has not been permanently adjusted, is to uncouple the valve rod *A* and set the eccentric rod so that the rocker arm will travel equal distances from its vertical position. The reach rod *A* should next be adjusted to a length that when the engine is set on crank dead center the roller just touches the cam of the crank-end valve. The rod *F* is next adjusted by the sleeve *E* to cause the head-end roller to touch its cam when the crank is at head-end dead center.

To set the auxiliary exhaust valves, the manufacturers provide an opening into which a relief valve is

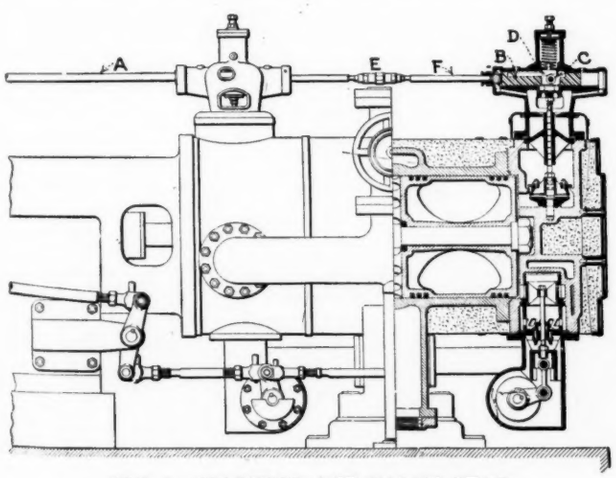

FIG. 4—CYLINDER AND VALVE GEAR

screwed, whereby the engineer can see the auxiliary port slots through the exhaust-valve cage. The valve is set so that the top edge is in line with the lower edge of the slots when wide open. In other words, the valve opens wide, without any overtravel. When closed, the lap is practically one and one-half times the length of the slots. This is necessary in order to keep the valve closed over half the engine's revolution. After setting the two auxiliary valves so that their travels and positions are as near alike as possible by changing the valve stem and reach-rod lengths, the exhaust eccentric should be shifted to give a small amount of lead with the engine on dead center. If the two valves do not show the same lead, correction may be made by adjusting the rocker arm to give equal travel from its vertical position and by changing the length of reach rods.

A final adjustment of all valves should be made after the engine has been run awhile. Indicator diagrams

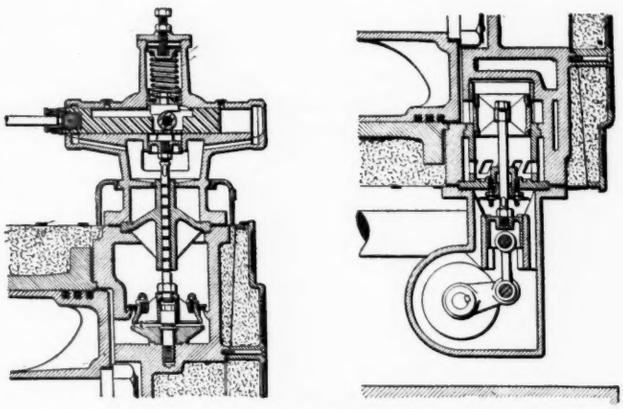

FIG. 5—STEAM AND AUXILIARY EXHAUST VALVES

should be taken in order to find if the valve setting gives a balanced condition to the two cylinder ends. The auxiliary exhaust valves must be set to give correct compression under the existing back-pressure conditions. When operating condensing, the auxiliary valves are uncoupled or left off entirely.

Should Coal Be Purchased on the B.t.u. Basis?

By T. A. Marsh*

Why should coal be purchased on the basis of the greatest number of B.t.u. per dollar? In the abstract do we really care how many B.t.u. are purchased? The calorimeter indicates the number of B.t.u., but does not tell the storing qualities, the efficiency of firing under average load conditions, the labor incurred in steam production, the maintenance, the capacity obtainable, or even whether the coal can be burned on the grates without frequent shutdowns.

The ultimate aim is the production of cheap steam. Only to the extent that the greatest number of B.t.u. per unit contributes to this end is the user interested. Steam cost embraces capital charges, fuel cost, efficiency of operation, labor and maintenance.

Every plant has its minimum limit in operating capacity. Certain inferior coals might be purchased that would make cheap steam and permit of low labor and maintenance costs, but still be useless if the plant could not make sufficient steam. The use of such fuel, of course, entails the installation of extra boilers, stokers, settings, stacks, ash-handling equipment and building extensions, thereby increasing the capital investment perhaps to a point where the ultimate cost of steam is higher than with other coals from which greater capacity could be obtained, even if the cost per 1,000 B.t.u. were greater. When a plant is to be designed, the kind of coal that is to be used will influence the selection of equipment and have a bearing on the

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capital investment as well as the cost of steam production.

The four other items—fuel cost, efficiency, labor and maintenance—are directly affected by the quality of the coal used. Frequently, the coal containing the lowest number of B.t.u. per dollar can be burned at higher efficiency, so that the fuel item is lower than with coals of higher heat content.

There are, throughout the country, coals that are disproportionately cheap because of their firing characteristics. They contain a high percentage of ash or may clinker easily, thereby causing increased labor in cleaning the fires and in ash removal. Such coals may have to be avoided if the labor item increases more rapidly than the purchase price decreases.

Then there are coals relatively cheap on a B.t.u. basis because they are of a class that cause high maintenance to grates and furnaces. These coals also must be avoided if maintenance charges and the loss of boilers from service are disproportionately high.

Purchasing coal, therefore, to produce the cheapest steam, becomes a problem only partly dependent upon the number of B.t.u. per dollar. Considering all the items enumerated, the method of approaching this problem is to consider the entire fuel situation tributary to the locality. Select the coals that can be supplied in sufficient quantity and with assurance of continuity of supply from reputable coal companies. If storage is involved, the coals that can be properly stored must be given preference, as the loss of fuel or of heat value by storage fires is a sure road to increased steam costs.

The analysis will resolve itself usually into a selection of three or four coals, as it is unnecessary to select more than one or two coals from a district or seam to determine what can be done with that particuler kind of fuel. To guard against low capacity or shutdowns due to maintenance troubles or other causes, the initial purchases of these coals should be limited. They should be burned separately in the regular routine of daily plant operation for a month or more, accurate records being kept during this period to arrive at the actual day-in and day-out, peak load, average load and banking performances under no special supervision, but with the regular operating organization and routine.

Such periods of operation will provide reasonable study of maintenance, labor in firing and ash handling and in addition will cover a sufficient quantity of coal to give a good indication of how the fuel will actually run on monthly averages compared to samples supplied for test purposes. Such an analysis cannot be made without a suitable accounting system to charge to the cost of steam production all items entering into it. For each coal under 30 days' test a separate analysis of costs should be made, giving more weight to observations regarding maintenance than to actual figures, as a 30-day period is not long enough to accurately determine this item.

It must not be concluded that short tests with special supervision have no value; they may be useful as studies leading to improvements in furnaces, in boilers and in operating methods. Test conditions, however, are so far removed from actual operating conditions in regard to load, banking periods, firing supervision, instruments for observation, condition of equipment and other items as to make coal comparisons on test results of little value.

Reduced to a few words, the proper coal to purchase is that which goes to make the lowest ultimate steam cost. The only place that such a determination can be made is in the plant and under regular operating conditions.

When the fuel that will make the cheapest steam has been selected, then the analysis and heat value should be determined and if possible the limits of tolerance should be established, so that it can be determined whether the same coal is being supplied within reasonable limits of variation occurring in production and preparation.

Utilizes Combustible in Ash

By C. O. Sandstrom

Loss of fuel in the ashes varies from 15 per cent (based on the weight of the ashes) in the best plants, to 25 per cent in the average plants, and upward of 50 per cent in the poorer, or less efficiently operated plants. In addition to the fuel loss there is a loss incident to the removal of the ashes. A few plants are favored by being able to sell their ashes, but the price received is seldom more than $5 for a 50-ton car, or 10c. a ton.

Ashes, or clinker, has been used to a limited extent in concrete construction for many years and has the advantage of cheapness and light weight. A disadvantage, however, in reinforced-concrete construction is the danger of corrosive action on the steel.

There is now being developed a process for recovering the heat value of ashes and at the same time producing from the residue a perfect clinker, free from injurious substances, and which makes an excellent aggregate for concrete. This process (which is known as the Klinkerag Process) takes the ashes or refuse from boiler plants, oil refineries, smelters and other industrial establishments, burns out the combustible matter and fuses the residue to a clinker; this is accomplished in a rotary furnace. In passing down through the furnace, the refuse is subjected progressively to the evaporation of the contained moisture, the burning of the combustible matter and the clinkering of the residue. From the furnace the clinker is passed through a rotary cooler which cools it to the point of convenient handling and preheats the air going to the furnace. From the cooler the clinker is passed through a screen; the large pieces run through a crusher and are broken to the required sizes. The product of the crushing plant will vary in size from sand to the coarse aggregate used in concrete construction. The hot gases from the furnace (upward of 2,200 deg. F.) are passed through steam boilers or other heat-absorbing apparatus. A small amount of auxiliary oil fuel is burned at the lower end of the furnace to maintain clinkering temperature.

The clinker produced by this process is susceptible of chemical control; that is, should a product of higher silica content be desired, sand is added to the required amount. Likewise the iron, alumina and lime content may be varied by the addition of iron ore, waste iron (tin cans and junk), clay and limestone. This control permits the production of clinker varying in density, hardness and toughness. Colors may even be obtained by the addition of low-grade metallic ores.

An ideal location for a Klinkerag plant is at a boiler plant (or in connection with other heat-absorbing apparatus) and in proximity to a supply of fuel-carrying refuse and a market for the clinker. Either the heat or the clinker will pay a large profit on operation, so the one or the other may be deemed a byproduct.

Keeping Oil Out of the Refrigerating System

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

AFTER lubricating oil enters the ammonia compressor cylinder, it can get out only through the discharge valves with the ammonia vapor. Should excessive quantities be fed to the cylinder so that the oil cannot evaporate quickly and be carried out of the cylinder, it is likely to decompose with the formation of carbon deposits, particularly on the discharge valves. The deposits interfere with the operation of the valves and lower the efficiency of the system. They can be eliminated by the use of fairly volatile oils and a minimum feed.

The vaporized oil leaving the cylinder with the ammonia at the temperature corresponding to the ammonia temperature at the discharge pressure, normally from 200 to 300 deg. F., begins to condense at once as the ammonia begins to cool. The hydrocarbons of which the oil is composed have different boiling points and therefore have different condensation temperatures. Those constituents with the highest boiling points condense first and those with lower boiling points later. This process is similar to that by which the oil was originally condensed from the vapor in the refinery.

If an oil separator is placed between the ammonia cylinder and the condenser coils, a part of the oil will be separated and can be withdrawn from the system at this point. Only that part of the oil can be removed which has been condensed by the temperature reduction up to the separator. That means that only the heaviest hydrocarbons will be condensed and removed by the separator, the lighter fractions being carried along with the ammonia in a vapor form. The farther the separator is from the cylinder and the lower the temperature of the ammonia at the time it reaches the separator, the greater will be the amount of oil removed.

Condensation of Oil in the System

When the ammonia passes through the condenser coils, the vapor is cooled and some of the oil vapor condenses here. It collects in the bottom of the ammonia receiver, and if a drain valve is opened at this point liquid oil can be removed. This collection of oil will be lighter in viscosity, higher in gravity and lower in boiling point than the oil collected in the oil trap.

Oil and ammonia are soluble to a certain extent, and when the ammonia passes through the expansion valve, it carries with it a considerable amount of oil, a part of which vaporizes, although the greater amount condenses and flows through the expansion coils in a liquid state. Should another trap or separator be placed at the suction end of the expansion coils, it will be possible to remove liquid oil that will be lighter in gravity and viscosity than any previously separated and much more volatile.

Going back for a moment to the exit of the oil from the ammonia cylinder, we find that in addition to the vaporized oil there is a certain amount of carbonized oil caused by a partial "cracking" or decomposition of the oil due to the temperature and pressure. This carbonized oil is almost always removed entirely by the first separator. The extent of carbonization depends, of course, upon the characteristics of the oil and the operating conditions of the compressor. As a general thing, if the oil is fairly volatile, it will evaporate quickly and will be removed from the cylinder before there is time for very much decomposition to take place.

The oil removed from the ammonia receiver and from the trap at the end of the expansion coils, as a rule, is quite clean and free from carbon. A clean oil—that is, one free from decomposed oil and carbon—even though it may have a high pour test, or congealing temperature, will cause little serious damage other than a temporary delay necessary to warm up the coils slightly to melt it out. As soon as it melts, it will run to the trap and may be drained out. A thin oil, or one of low viscosity, can be removed much more readily than one of high viscosity.

If the oil decomposes and is then carried through to the expansion coils, it will form a gummy mass on the coils when frozen and will insulate the pipe, lowering the efficiency of the refrigerating system. Such a collection of sludge cannot be removed from the pipes by the simple process of warming; it usually requires steam blowing and a thorough cleaning of the system afterward with air to eliminate the moisture.

Water Causes Emulsion

Should there be any moisture in the system, it will absorb the ammonia, and the resulting solution has great tendency to emulsify the oil, particularly if the oil has been slightly decomposed owing to the temperatures in the discharge line of the compressor. The emulsified oil can be removed from the traps readily provided the emulsification occurs before the ammonia reaches the expansion valve. If the emulsion reaches the expansion coils, the low temperature freezes the water and the emulsion coats the pipes and reduces the refrigeration through insulation. All engineers are careful to prevent moisture from getting into the ammonia on account of its freezing in the coils, but some do not recognize the serious troubles that may come from emulsions due to water. An emulsion in the lines almost always necessitates the use of steam blowing before it can be removed.

Q. Can the oil drained from the traps of an ammonia refrigeration system be used over again in the compressor cylinders?

A. The oil drained from the separator just before the condenser coils contains much carbon, which should be completely removed by careful filtration or centrifuging. This oil will be too high in viscosity.

The oil drained from the other traps will usually be fairly clean, but may contain some moisture. It should also be filtered to make it safe. This oil will be too light in viscosity.

If all of the oil collected is mixed together, the combination will usually be satisfactory from the viewpoint of viscosity and pour test, and its re-use will permit a reduction in the cost of lubrication.

Q. Is it possible for a non-condensible gas to form

in the ammonia system through decomposition of the oil?

A. The only gas that might be formed from decomposition of the oil would be methane or butane, which have very low boiling points. It is extremely doubtful if these can be formed under the conditions that exist in the ammonia compressor of any part of the system.

All analyses of such gases or vapors that the writer has seen, have indicated that the non-condensible gas was nothing more nor less than plain, ordinary, every-day atmospheric air. When such a gas collects, the first thing to do is to examine the whole system carefully to find out where the air is getting into it.

Justifiable Coercion

By J. P. Morrison

The owner of a plant frequently objects to criticism of his boiler and wishes to continue it in operation, even to the extent of spending more money for repairs than the value of the boiler will justify, to say nothing of the total absence of economy, where the older boilers, comparatively low pressure, and dilapidated furnace walls are encountered, and of the extra hazard attending the use of a boiler whose safety is open to question.

The plant owner who has had a slight amount of stationary engineering experience in his youth, is prone

FIG. 1—THE PENALTY FOR DISREGARDING INSPECTOR'S ADVICE

to overrate his knowledge of boilers, and as years go by, the undesirable conditions he sometimes encountered as a youth are likely to leave the impression that they were the general rather than the exceptional condition. So the distinct recollection of one overloaded safety valve is multiplied until he has an idea that in the dim past all safety valves were loaded to the pressure desirable to operate the machinery, regardless of the strength of the boilers.

Engineering ability, wherever found, is worthy of recognition, and the fireman frequently can give information on some detail that may have caused his superiors to worry, but the knowledge gained in a plant where the employees compound a secret scale solvent and adjust the safety valves to suit the load conditions, is not of the dependable sort and, if relied upon too firmly by the executive of a manufacturing organization, is likely to lead to grief.

The story is clearly illustrated by Fig. 1, which is a view of the ruins of a wood-working plant in the Middle West. The plant contained two horizontal-tubular boilers of uncertain age. One of these was constructed of three rings of two sheets each. A large patch had been placed in the fire sheet, and the added seams gave the boiler something of the appearance of an old-fashioned crazy quilt. The manhole was in the upper part of the middle ring and was placed with its major axis longitudinally of the boiler. The manhole reinforcement was of cast iron and secured so it projected above the boiler.

A crack developed in the shell plate between the manhole opening and the girth seam. This crack was

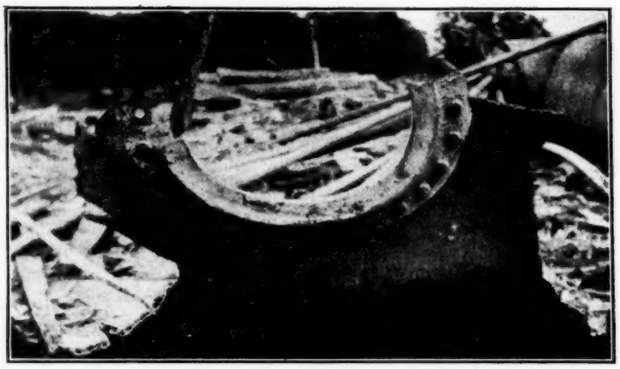

FIG. 2—SHOWS ATTACHMENT OF MANHOLE

closed by applying a small patch (see Figs. 2 and 3). The stresses that had produced the crack in the shell plate had also affected the cast-iron manhole reinforcement, but no consideration was given to this condition, nor to the fact that the boiler should be consigned to the scrap pile on general principles.

The owner, in discussing the boiler with the inspector, relied upon that knowledge of engineering which he had acquired as a boy, and possibly had somewhat of the feeling that an inspector is a nuisance, which in some locations does not have to be tolerated, so followed his own judgment.

When the inevitable resulted, and the owner realized

FIG. 3—A SMALL PATCH HAD BEEN APPLIED NEAR THE MANHOLE

he had no insurance protection, he exclaimed to the inspector: "Why in the H— didn't you make me do it?"

But this contrition did not restore the two lives that were lost nor rebuild the plant. However, if those power-plant operators, who receive recommendations for improvements, can be brought to realize the mental anguish which compelled the cry, "Why didn't you make me do it?" that exclamation will have a wonderful far-reaching influence and be entitled to a place in history with "Don't give up the ship," and "Carry a big stick."

Operation and Maintenance of Alternating Current Generators

By RALPH BROWN*

AFTER a generator is placed in service, constant vibration, recurring temperature changes, occasional short-circuits, and high-voltage surges tend to impair the qualities of any insulating material. Oil-soaked armature-coil insulation has a tendency to deteriorate rapidly, defective connections in the armature and field circuits may burn apart, and accumulations of dirt in vent ducts and on coils cause excessive temperatures.

Some of these troubles may result in a burnout before there is any indication of their existence if only an external or careless inspection is made. When the failure does occur, the evidence of the cause would probably be destroyed. For these and other reasons it is highly advisable to inspect generators thoroughly at intervals of six months.

With vertical generators access to the interior can generally be gained from the bottom or the top. It will usually be necessary to remove the end bells of horizontal generators to gain access to the interior thereof, and even in the case of the largest units experience and study will indicate that by using suitable tools, slings, etc., the end bells can be quickly removed and replaced. It should be determined by inspection that all slot wedges are tight and in place. Owing to shrinkage, these wedges sometimes work out of the slots. The coil insulation should be in good condition, not chafed, torn or unwrapped. All cord lashings must be tight, spacing blocks in place, and the entire winding and blocking and clamps in condition to resist, as intended, short-circuit stresses. All coils must be tight in the slots, there should be no distortion of the coils, and connections between coils and to the generator leads should disclose no signs of heating. The entire winding must be kept well varnished, and inspections will indicate when revarnishing becomes necessary. The windings and vent ducts must be kept free of dirt, and particular attention must be directed toward the location and stoppage of oil leaks. Vertical generators have been found in regular operation with their windings oil-soaked owing to oil leaks, but this is an abnormal condition that should never exist. If the conditions are not remedied, they will ultimately result in damage amounting to much more than the cost of preventing oil-soaked windings.

All bolts and nuts must be tight, and particular attention should be directed to the lamination clamping fingers. Instances are known where these fingers have broken off and been drawn to the field poles, with disastrous results. Loose laminations should be watched for, and this trouble can usually be detected by sound. Field coils should be examined for evidence of charring or disintegrating of the insulation between turns, and all the field-circuit connections should be free of any indications of abnormal heating. Collector rings should run true, their surfaces being kept free of grooves; brushes and brush-holders should be in good condition and free of dirt and oil. The air gaps should be checked occasionally.

Some of the inspections referred to, such as those of brushes and collector rings, and to detect oil leaks, should be made at monthly intervals. The practice of cleaning windings at frequent intervals is excellent insurance against generator troubles, but the desirable frequency of such cleaning depends entirely on local conditions. Even where the air that cools large vertical generators is fairly free from dirt, the windings, if the generators can be spared and if the work can be done during a few hours a day for two or three days, should be cleaned at monthly intervals. Where generators cannot be conveniently spared and where considerable work must be done before cleaning can proceed, such work should be undertaken only when frequent inspections indicate that it is advisable or necessary. In general, it is better to err in cleaning too frequently than not often enough. In cleaning large generators, compressed air at a pressure of about 80 lb. per sq.in. is used to dislodge as much dirt as possible. Rubber hose only, to avoid damage to the insulation, is used within the machine, and care must be taken to blow all entrapped moisture from the air system before directing the nozzle on the windings. While the air pressure recommended is somewhat high, it will not damage the winding unless the nozzle is held too close to the taping. Particular attention should be paid to cleaning the vent ducts through the core, these being blown from outside and inside the stator frame. If the dirt is difficult to dislodge, a section of the duct can be covered with pads made of sheet packing, and the nozzle inserted through an opening therein. Specially shaped nozzles can be made to dislodge the dirt from difficult places. After as much dirt as possible is removed by blowing, the windings should be thoroughly wiped with rags. Generally one-third of the time spent in cleaning will be devoted to wiping. Because blowing the dirt from one generator in such manner that it will settle on other apparatus partly defeats the object of cleaning, the machine undergoing cleaning should be isolated by a canvas cover or otherwise. This, however, is not generally done.

If insulation is kept well varnished, its life will be increased and much less work will be required to keep the winding, of which insulation constitutes such an

MERELY because a generator will operate for a long period without external evidence of trouble this should not be construed as a reason for omitting regular inspections of this class of equipment. Because of the excellence of generator design, as evidenced by the satisfactory operation of units that are given but little attention, operating men are sometimes tempted to forget certain factors that, if too long neglected, will result in serious difficulties.

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important part, in good condition. In order that there shall be no tendency for mixtures of unlike varnishes to decompose or for chemical reactions harmful to the insulation to develop due to the indiscriminate mixing of varnishes, it must be definitely known that the varnish to be used will prove satisfactory. Manufacturers of electrical machinery are best able to recommend suitable varnishes for their equipments, and are glad of the opportunity to do so. Varnish or insulating paint can best be applied to the windings of generators and similar equipment by means of an air brush.

Practically all large generators are equipped with thermocouples or resistance coils, which indicate on suitable instruments the internal temperatures of the winding and core, thereby making it possible to operate a machine at its maximum kilovolt-ampere output without exceeding the specified temperature limit. It is important that temperature-indicator apparatus be kept in order. The temperature indicated by the hottest coil is generally recorded hourly, but it is well to take and record the temperatures of all coils at monthly intervals. By checking these records month by month, any relative changes of coil temperatures can be noted and the cause, such as clogged vent ducts, ascertained and corrected.

Megger Should Be Used

Since the resistance of insulation can be quickly meas ured, without strain, by a megger, it is advisable to use this instrument to ascertain the insulation resistance between the winding and the stator frame at intervals of six months and record the values indicated. It is thought that a voltage 125 per cent of normal, produced by the generator itself and maintained for one minute at yearly intervals, is sufficient for a breakdown test. So far as puncturing is concerned, a generator should operate for a long period at a voltage 25 per cent above normal, but it is not good practice to subject insulation to stress merely for testing.

Owing to water becoming entrapped in conduit and to other causes, a generator may become grounded, and this trouble is best indicated by a ground detector. Although there is prejudice against the use of this instrument in some generating stations, the fact that the original cause of many generator burnouts is a grounded conductor is an excellent reason why ground detectors should be more extensively used.

If a generator develops electrical trouble, it is highly important that it be immediately disconnected from the bus, followed by the opening of its field breaker. In order to insure better service and to eliminate the human element at this critical moment, differential or directional current relays are frequently used to cut out the generator on the occurrence of internal trouble. Because these relays, if properly cared for, will greatly limit the damage that may result from a generator burnout, and their cost, is relatively small, it would seem that their use would be much more widespread. In order to determine that they are in proper operative condition, relays protecting generators should be tested semi-annually.

The eight chief factors producing heat loss in boiler operation are: Heat carried off by the flue gases, incomplete combustion, unburned carbon escaping up the chimney or depositing in the boiler, unburned carbon in the ashes, moisture in the fuel, formation of water by the combustion of hydrogen, water vapor in the air and radiation.

Advantages in Compound Compression

By John E. Starr
Consulting Refrigerating Engineer, New York

Of late a good deal has been heard in the trade on the subject of compound compression. Two definitions of this term in a commercial sense may be given. One is compounding pure and simple, as in a refrigerating process, taking up heat from the object to be cooled all on the same plane, and another is compounding *including* the benefits that may accrue from taking up some of the heat on a higher plane, such as the taking up part of the "heat of the liquid" at an intermediate back pressure, or perhaps also some other high-pressure work, such as the partial cooling of water from which ice is to be made.

Regarding pure compounding it may be said that the chief benefit of so handling the working fluid lies in the fact that when compound compression is used the heat head between the hot and the cold side of the cylinder is reduced and so the "slip back" of heat is reduced. If the gas after each stroke of the piston is compressed, it is of course heated by compression. A certain amount of this heat is conducted back to the cold incoming gas by the metal walls of the cylinder and by the metal piston. This heat swells the incoming gas, making it occupy more volume per pound, and it therefore requires more power to compress it per pound than would be needed if this increase in volume had not occurred. The relation of the volume of gas per pound as it comes to the compressor to the volume per pound actually handled by compressor displacement, is sometimes known as the "volumetric efficiency." The amount of heat that a pound of liquid will take up is nearly the same at all operating pressures, but the volume of a pound may vary greatly with pressure.

The true volumetric efficiency of the compressor, or exact measure of its volumetric performance, is the relation of the volume of gas per pound actually handled by the compressor to its volume per pound at entrance to the compressor at the suction valve.

Its volume per pound at this point is usually a little more than its volume per pound immediately on leaving the boiling liquid, but as the operator is largely concerned in the volume per pound as it leaves the evaporator, it is simpler and more direct to compare the actual volume of the compressor figured from the piston displacement to the volume of the ammonia in a saturated condition.

The increase in volume by reason of heat picked up on the way from the evaporator to the compressor is of no refrigerating value and is usually, or should be usually, very small. Of course, in the case of long suction pipes it should be taken into account in getting at the true volumetric efficiency, but it can be neglected commercially. The mechanical slip of gas is usually very small, but it would be included if the calculated displacement was used in the compressor.

The rate at which the heat slips back depends on the difference of heat head and therefore on the ratio of compression. It is relatively higher as the ratio is greater, as is evidenced by the fact that the volumetric efficiency decreases as the ratio of compression increases.

If single-stage compression is followed, the difference between the temperature of the discharge gas and the suction gas will be much greater than any difference

that will exist between the gas compressed part way and suction.

The volumetric efficiency of a simple single-acting compressor may run from 74.5 to 85.5 per cent and may reach the former figure at about 11 compressions. But a machine calling for a ratio of 11 when operating simple, may, when compounded, call for a ratio of only 2½ or 3½ in each cylinder where the volumetric efficiency may be 88 or 89 per cent. At lower ratios the compound machine has in actual practice realized an efficiency around 95 per cent.

In short, at ratios from suction to discharge from 3 to, say, 6 or 7, there is only small saving by compounding to obtain a reduction in the ratio, but when the ratio is 8 to 11 if running simple, it would be only 2½ or 3½ when running compound, and the saving of power is considerable. Therefore, as to compounding alone there is indication for its use where heat has to be taken up, say, below —20 deg., as in fish freezing and cold-storage work, where back pressures near the atmospheric pressure for ammonia are involved, or it might be used where temperatures are higher and cooling water scarce or warm.

An important series of accurate tests made by Frank Horne on a compound machine gives valuable data on this subject. At various ratios of compression, ranging from about one pound below the atmosphere to 14 lb. above and at heads from 85 to 210 lb. gage, he obtained results in horsepower per ton as follows:

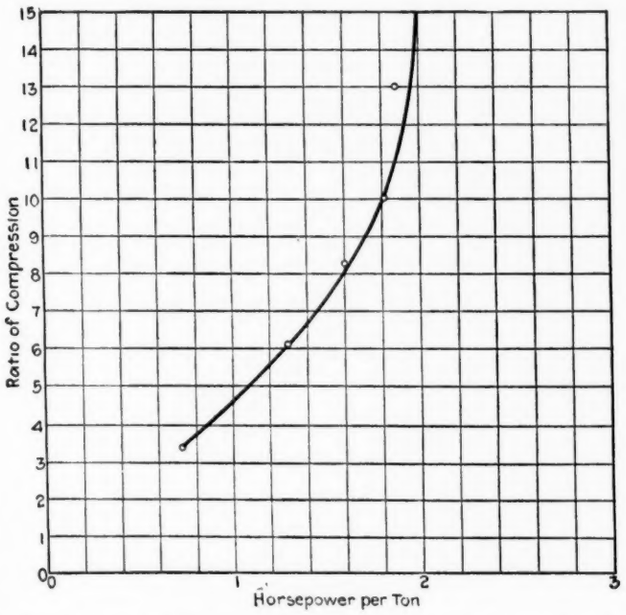
Ratio of Absolute Pressures	Head Pressure, Lb. Gage	Back Pressure, Lb. Gage	Horsepower, Per Ton
10	190.3	4.8	1.73
9.67	135.3	0.8	1.69
16.05	210.3	0.7	2.013
12.8	165.3	—0.7	1.87
3.44	85.3	14.3	0.978
6.35	147.3	+0.8	1.34
8.26	105.3	—0.2	1.41

These horsepower per ton figures, when plotted against ratios of compression, give a fairly regular curve, as shown in the accompanying figure. The results show a somewhat better performance at all ratios than those obtained with simple compression, but owing to the fact that with the same final temperatures at which the heat was taken in and discharged, the simple compressor would have a high ratio and the compound a lower ratio, the figures would be largely in favor of the compound method at the larger differences, and at, say, anything over 9 or 10 compressions with simple compression the saving would run in large machines into so much money as would merit consideration of costs of installation of machine.

So far reference has been made only to compounding by itself as compared to simple compression, but there are some items that can go with compounding that should not be overlooked. In the first place the liquid can be forecooled at less expense. Suppose the intermediate pressure is at 65 lb. absolute pressure. The ammonia as it leaves the condenser can be exposed to this pressure, and at this pressure of 65 lb. a part may be evaporated, and the liquid may run to the expansion valve at a temperature of 34.07 instead of condenser temperature, which may be 80 or more, this being as low as the cooling water will get it. Suppose the evaporating temperature is +5 deg. F. One need only to cool the liquid from 34.07 to +5 deg. instead of from 80 to 5 deg. The 46 deg. taken out of the liquid in cooling from 80 to 34, to be sure, requires refrigerating work, but the work can be done cheaper in cooling at 34 deg. than in cooling at 5 deg., for the volume of one pound of gas at 34.07 lb. pressure is only 4.46, while it is 8.149 at 5 deg. and it has to be compressed up only from 65 lb. at 34 deg. and from 34 lb. at 5. Here is roughly a saving of 4.5 per cent in power.

A further suggestion is made that it is also possible to considerably forecool the water, out of which ice is to be made, at the intermediate pressure. By a simple compression from intermediate to high the incoming water can be cooled to somewhere near the boiling point of the working fluid (in this case 34.07 deg.), leaving less work for the lowest-pressure gas to accomplish. Of course some work must be done in the high-pressure cylinder to forecool this water, but it will not be so much work as if cooled in the usual manner.

There is, theoretically, under the average conditions about 9 per cent saving in this method. Added to liquid cooling a total net gain of 12 or 13 per cent might be



RELATION OF COMPRESSION RATIO TO HORSEPOWER PER TON

realized, which, added to the gain in compounding, would probably be the last word in ice production so far as power goes.

There is a growing demand, especially in certain chemical industries, for refrigeration at lower temperatures than have usually been obtained by the commercial refrigerating machinery on the market. The average requirements have so far been met by machines taking up heat from zero to 5 above for ice making, and from 10 to 20 below zero for cold storage and fish freezing. A demand is growing in certain directions for temperatures of 60 and 75 below zero. For this work a simple compression machine is hardly to be thought of, and if the compression system is to be used, compound or even triple compression would be the cheapest method, but other ways have been suggested which claim to do the work cheaper than compound compression could possibly do it. The cost of apparatus, if compound compression was used, would be against it, for compared to a machine taking up heat at, say, zero, the low-pressure cylinder of a compound compression machine taking up heat at —75 deg. F. would have to be about seven times larger and the engine would have to deliver over twice the horsepower per unit of refrigeration.

British Blast-Furnace Gas Engines

THERE still lingers a certain amount of prejudice among British engineers against blast-furnace gas engines. There certainly have been failures with them in the past, although several of these can be attributed to the quality, or rather condition, of the gas supply. It is also argued that the price is somewhat against them, the construction of necessity being expensive. To a great extent this is due to the fact that these engines are slow running, and the peculiar slow burning qualities of blast-furnace gas render this more or less essential. The question arises as to their exact field of usefulness. The answer is at once iron and steel works. A large proportion of the gas produced by blast furnaces is a waste product, and although it can be easily burned under boilers, it is a wasteful procedure as compared with its use in gas engines.

Design of Large Gas Engines

The British gas engine of orthodox design as applied to small and moderate powers is well known to American engineers, and as a first-class prime mover in its own special sphere is probably without a rival. In Great Britain, however, the advance of the large engine has been slow as compared with America, Germany and Belgium, these having been staunch adherents of the tandem horizontal design since its introduction some twenty years ago. The original engine of the design now generally accepted for utilizing blast-furnace gas was introduced by the Cockerill Company (Belgium) in 1898 and was of 200 hp., another one, similar but of higher power, being exhibited at the Paris Exhibition in 1900. The latter really marks the beginning of the evolution of the high-power gas engine as it is understood today. It was not, however, till a

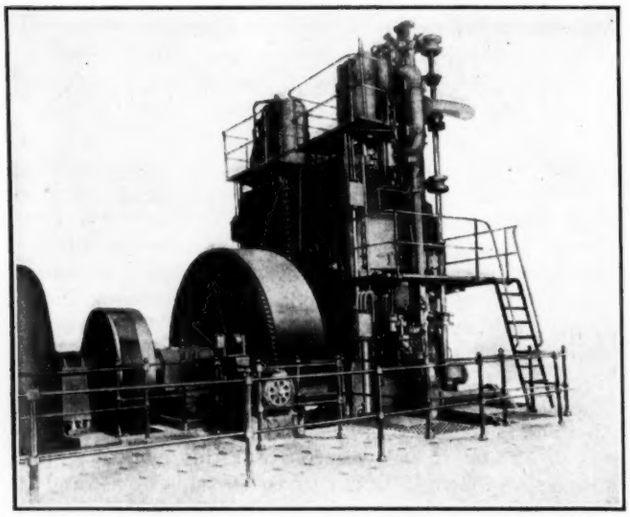


FIG. 1.—PREMIER SLOW-SPEED VERTICAL GAS ENGINE

year or so later that the double-acting tandem type was introduced as a commercial proposition. In the meantime Westinghouse had introduced the three-cylinder vertical engine, which was taken up by Crossleys, the National Company and others, and gradually developed into the now well-known three-crank six-cylinder pattern as a high-speed engine of considerable power. These engines have been successfully operated on blast-furnace gas, but are not considered ideal for the purpose. The Fullagar opposed-piston principle has been used in gas engines, but not to any great extent. The two-stroke-cycle system has been tried both in England and elsewhere, but has been practically discarded in favor of the four-stroke-cycle, few of the two-stroke engines having been really successful.

Of the high-speed vertical engines little need be said. They are well known as efficient and reliable prime

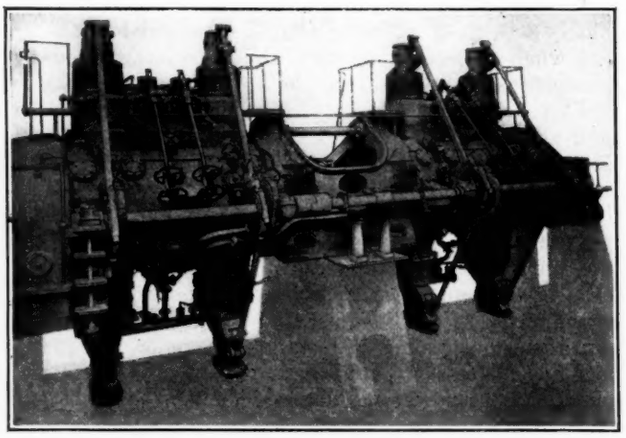


FIG. 2.—VICKERS TANDEM DOUBLE-ACTING GAS ENGINE

movers. The general design is now practically standardized on the three-crank six-cylinder arrangement, the engines being all four-stroke and single-acting. Units with eight cylinders and four cranks are also being built; in fact, with standardized parts a wide range of sizes is available with this pattern. Engines of 600 hp. have been recently built by the National Company to this design. The main feature consists of the arrangement of the tandem vertical single-acting cylinders. They are arranged so that the top and bottom cylinders fire alternately, while below the top piston and the cover of the bottom cylinder is a compression space which acts as a buffer for the reciprocating parts on the down stroke. The compression of the mixture effects the cushioning on the up stroke. The top cylinders are of slightly larger diameter than the lower ones, so that the lower piston can be drawn right out of the engine. The valves are operated from a revolving camshaft by plungers and push rods, the exhaust valves being operated direct and the inlet through rocking levers. Forced lubrication is provided throughout, and the engine is governed by throttling on the "quantity" principle in conjunction with a mixing valve. Ignition is by high-tension magneto and starting by compressed air.

Large British Engines

At the present time the Premier engine (Fig. 1) is the only slow-speed vertical engine being built. It is quite a recent innovation in high-power gas-engine design, the main idea being to obtain a slow-speed engine economical of floor space. The general arrangement is in the form of a large letter H, the four double-acting cylinders being at the corners and the crankshaft in the lower middle. The cylinders are thus grouped in pairs on opposite sides of the crankshaft with a triangular connecting rod transmitting motion

to a single crank. There are several details of interest in this design, their main object being simplicity and accessibility of the moving parts. The latter are entirely inclosed and provided with forced lubrication, that to the cylinders being separate. Compared with the horizontal engine the cylinder castings are of simple construction. The pistons are water-cooled in accordance with the usual practice for double-acting engines, this being provided for by means of a telescopic joint alongside each pair of piston rods, the water being distributed from a box bolted to the side of the crosshead. The valves are operated by rocking levers actuated by external revolving camshafts, as seen in the photograph. Governing is on the "quality" principle, butterfly valves being actuated by the governor for this purpose. The cylinders of the engine shown are 24¾ in. in diameter, the stroke being 30 in., giving a piston speed of 625 ft. per min. at normal revolutions. The mean effective pressure is 66 lb. per sq.in. These engines are being built in units of 1,000 horsepower.

Double-Acting Gas Engines

The horizontal double-acting high-power gas engine has been in successful operation on the European Continent for many years. There are now three principal builders of these engines in England. They are proceeding along more or less orthodox lines as regards the general arrangement and in the adoption of two four-stroke double-acting cylinders in tandem, twin sets working on a common crankshaft being installed for very large powers.

The Vickers engine, shown in Fig. 2, is typical of its class and is designed for direct coupling to an alternator, but is easily adapted to driving blowing tubs.

The engine speed is 100 r.p.m., at which speed some 560 b.hp. is developed with a mean effective pressure of 67 lb. per sq.in. and a maximum pressure of 262 lb. per sq.in. For the driving of blowing tubs, the engine speed is 80 r.p.m. The cylinder diameter of the engine illustrated is 43.31 in., the stroke being 57.3 in. The liners are separate from the main casting, which is usual in these engines but not essential with the one-piece cylinder. The piston rods are 10.75 in. in diameter, ground on the outside and bored for the passage of the cooling water. The rod glands are packed with cast-iron rings split in three parts and held onto the rods by springs. The three outer rings are similar in form but made of white metal. These glands, in common with other working parts, are pressure lubricated, the oil passing through sight-feed glasses. The main bearing, crankpin, crosshead and slipper, however, are supplied with oil by gravity from an overhead tank.

The crankshaft is a one-piece forging with separate balance weights and is 21 in. in diameter at the bearings, the latter being of the four-brass, babbitt-lined and wedge-adjusted type. The outer bearings are provided with spherical seats.

Ignition Systems

Electric ignition is installed. This may be either high-tension or low-tension according to choice. The governing of this engine combines the "quality" and "quantity" systems. There is independent control for gas and air to each end of both cylinders; this is for use when the engine, installed as a blowing engine, is required to run at reduced speed, and also for starting-up purposes.

The valves are operated by a revolving layshaft, through eccentrics and rods, the exhaust valve being water-cooled and situated beneath. The eccentric system, however, is by no means usual with these engines, cams, in fact being more often used.

The Galloway engine as a whole follows accepted practice as regards general layout, and is very similar externally to the Vickers engine, although differing therefrom in several essentials. They are made in sizes ranging from 400 hp. with 25 in. diameter cylinders to 2,700 hp. with 55 in. diameter cylinders, the speeds varying from 150 r.p.m. in the small engines to 88 in the larger ones. The stroke is somewhat longer than the cylinder bore in each case. The valves are cam-operated from the layshaft, one cam actuating both valves for the one end of that cylinder to which it applies. The layshaft is driven from the mainshaft by gearing, the forged steel cams, which have hardened faces, being keyed on to it.

The crankshaft is built up; that is to say, while the Vickers engine employs a one-piece forging weighing some 20 tons and having the balance weights bolted to it, that adopted by Galloway is of the sweep-crank type, with cast-steel webs and pin in one piece shrunk onto the straight pieces, the main journals and shaft being finished after the shrinking operation. For governing, the somewhat radical departure of the servo-motor system has been applied, operated by oil pressure maintained by a gear-driven oil pump. It follows in the main the arrangement adopted to hydraulic-turbine governing, but of course comparatively small power is required for moving gas and air throttle valves as compared with that necessary to actuate a system of pivoted guides in a water turbine. The governor of the Vickers engine, on the other hand, is direct acting, but is of a powerful pattern with the moving parts running on ball bearings.

Future of the Gas Engine in Great Britain

There is little or nothing to warrant the inefficient methods of producing power hitherto so much in evidence in steel works and the allied industries. The modern blast-furnace gas engine is both reliable and efficient and should be installed in every mill. Whether very large gas engines have a future working with ordinary gas producers is a debatable point.

The advances made in the last few years have done much toward the improvement of the British engine. When prejudice against them is worn down and the remaining minor difficulties are overcome, they will no doubt play a greater part in the economical production of power and, incidentally, the conservation of our fuel resources.

It may be laid down as a good working principle that pumps, where possible, should be placed low enough so that they may be filled by gravity when not running. With the discharge valve closed and the suction valve open this makes priming automatic. Check valves should always be placed in the discharge line wherever the head is high or where more than one pump discharges into a common main. The check should be placed between pump and gate valve to prevent damage from water hammer and to allow the check to be repaired. The suction pipe should extend into the well or pond some distance to prevent the loss of suction by a whirlpool action at the surface of the water. If the pipe is insufficiently submerged, air will enter the line, the suction will be lost and the pump will need to be reprimed.

Getting Results from the Perpetual Motion Machine

Someone whose mind runs along research lines has found that an easy mark is born every second. The Automan Electric Company of New Jersey, builders-to-be of a perpetual motion machine, is modest. It does not expect to have a batting average of 100 per cent, but as Richard Ulram, the promoter of this plan of lightening the public's pocket, engages himself busily in mailing the glowing prospectus to names taken from the telephone books of cities as far west and south as Dallas, Texas, he has the attitude of one quite satisfied with the financial results.

In a prospectus issued two years or so ago, our friend Ulram announced that the only reason his perpetual motion machine would not run was the high price of mercury. He promised that as soon as he could procure a supply the machine would surely start to turn out

THE AUTOMAN ELECTRIC CO. FINDS PERPETUAL MOTION PROFITABLE

free power. Since the price of mercury has dropped, surely, the gullible public thought, Ulram has the old mill going at last. So upon receiving the big yellow circus poster which offered to let the public in on this wonderful invention, the man who wanted to invest in something that paid big hastened to Jersey City to gobble up all the shares not sold and at the same time to see this wonderful machine that would turn out power forever without paying a single cent of tribute to the coal trust.

Approaching the building, ears were strained to hear the sound of the whirling machinery that was destined to make (so Ulram claims) all the contributors millionaires. Not a sound of industry filled the air. The stillness was broken only by the scratching of Ulram's pen as he addressed his glowing bulletin to a long list of victims to be. In the corner, dusty and silent, stood the famous machine that a year ago refused to work all because of lack of a good drink of mercury. Since mercury has dropped in price, the old bogie of high cost can no longer be used as the excuse. Another one must be created to account for the lack of life in the mass of rods, pans and gear wheels. Fine! Nothing easier! Here it is. The machine will not run because the framing is made of cast iron, and since the mercury charge must be 8,000 lb., a steel frame is necessary. Of course Ulram finds it more advisable for his purpose to sell stock before making the change than it is to demonstrate the correctness of his claim by spending a few dollars to change the frame to steel; incidentally, even now part of the machine consists of odd pieces of strap iron or steel.

The machine, so all are informed, contains a series of vessels holding mercury. Two hollow tanks, also filled with mercury, are supposed, by alternately falling and moving sidewise, to cause the lower mercury vessels to swing like a pendulum and by so doing deliver power to a small drive pulley. Did the visitor want to see it run? Surely. So Ulram unlatches the machine and shows it will swing to one side until the second weight will almost release and throw the swinging mass back to its original position. Notice the word *almost*, for unfortunately the swing of the pendulum fails to quite do the trick. Ulram, by giving it a push, throws it against its stop, whereupon the second weight drops and the pendulum swings back, and the machine *almost* runs.

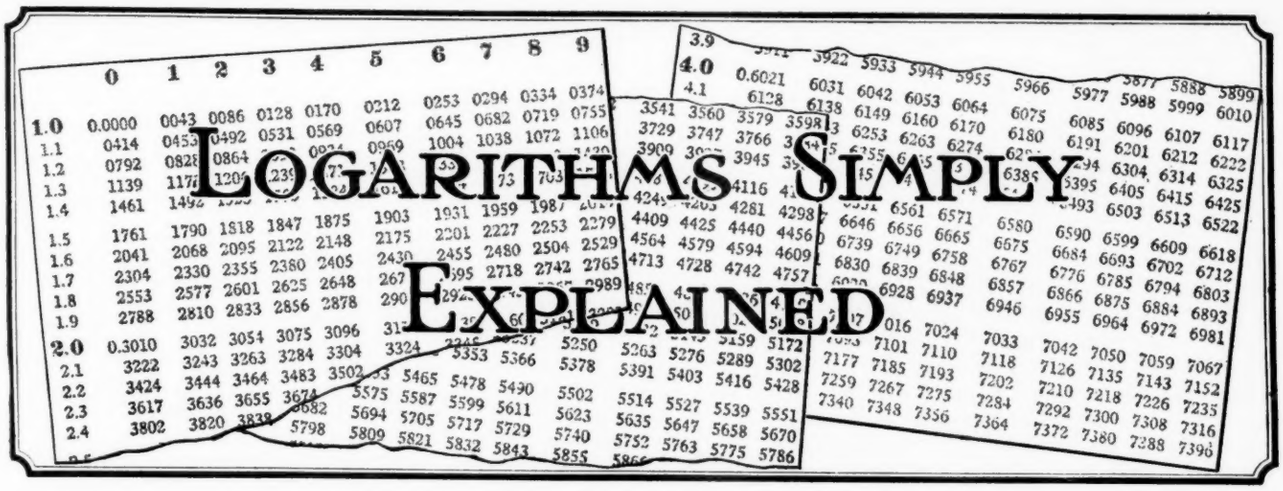
Anyone with the meagerest knowledge of mechanics could see that all Ulram has is a pendulum affair. As long as friction exists, the pendulum will never swing as far up as the height from which it fell. On top of this, even without frictional resistance, no useful power could be given out, for the pendulum at best could only run itself. One need not be a college professor to see that as long as we have weight resting on journals there is going to be frictional resistance. In addition, in the machine under question, there are a mass of joints, etc., all of which help to make the effort ludicrous.

While the victim was being converted, a young man, who from his appearance and speech, was a native of Poland, entered and laying $10 on the desk, received a receipt for the second payment on a share of stock in the Automan Electric Company. Trying to find why one so willing to part with this ten dollar bill should seem to be in such desperate circumstances as his appearance indicated, the visitor struck up a talk with the new arrival. He was, so he said, a striker on the New Jersey Central. He had been out of work since the first of July and was up against it. The landlord wanted his rent money, the butcher kicked for his meat bill, and the grocer no longer stood him off for his groceries. On top of this, the poor fellow said, with a suggestion of tears in his eyes, that his wife and four children were without shoes and that he didn't see how he was going to hold out until the strike was settled.

While the striker was telling his troubles, Ulram was busy posting the $10 payment in his ledger and making out a receipt. As he turned in his swivel chair to hand out the receipt, he consoled the poor devil by saying: "Of course it's a hard row, but just wait until we get our million horsepower machine going—then the babies can have their shoes!"

The world does not object to a man nursing a pet idea, no matter how impossible it be—just as long as he does not attempt to impose upon the public. But when a man or a company is willing to hoodwink others to the extent of taking the bread from the hungry, or shoes off the feet of babies, it is time to call a halt.

The Automan Electric Company is making the perpetual motion machine pay even if it doesn't run—but where does the innocent stockholder come in?



IN SPITE of the fact that most practical men class logarithms among the unknowable mysteries, the subject is really a simple one. Any reader who doubts this can satisfy himself in five minutes by following the first half-column of this discussion.

First write down in a line the numbers: 0, 1, 2, 3, etc., up to 10, and as many more as you wish. At the left of this line write the word "logarithms," or "log" for short. Just below this series of numbers, write another series starting with 1 and doubling each time, as follows: 1, 2, 4, 8, 16, etc. At the left of this line write "No." for number. Then you have the following:

Log	0	1	2	3	4	5	6	7	8	9	10	11	12	etc.
No.	1	2	4	8	16	32	64	128	256	512	1,024	2,048	4,096	etc.

Now suppose you want to multiply 32 by 128. First, add their logs to get a new log. The log of 32 is 5 and that of 128 is 7. Adding 5 and 7 gives 12. The table shows that 12 is the log of 4096, so 4096 is the product of 32 by 128. This may be written in the following form to stand out clearly:

Number	Log
32	5
× 128	+ 7
= 4,096	= 12
(product)	(sum)

Similarly, three or more numbers may be multiplied together by adding their logarithms to get the log of the product, as illustrated by the following solution to the problem $4 \times 32 \times 16 = ?$:

Number	Log
4	2
× 32	+ 5
× 16	+ 4
2,048	11
(product)	(sum)

Again, to divide 2,048 by 64, subtract the corresponding logs, and the difference is the log of the quotient:

Number	Log
2,048	11
÷ 64	− 6
32	5
(quotient)	(difference)

Next, suppose you want to get the cube of 16. Now 16^3 is nothing but $16 \times 16 \times 16$, so you will have:

Number	Log
16	4
× 16	+ 4
× 16	+ 4
4,096	12

This gives the correct answer: $16^3 = 4{,}096$, but why not multiply 4 by 3 instead of writing down 4 three times? In the case just considered, the elements have the following names:

16 = root
3 = exponent
4,096 = power

We found that the log of the root multiplied by the exponent equals the log of the power. Evidently this can be turned around to read: "The log of the power divided by the exponent equals the log of the root."

How To Apply the Rules

Let us apply those rules to a few simple problems in powers and roots:

Problem: $4^5 = ?$
Solution: Log 4 = 2; $2 \times 5 = 10$ = log 1,024
Therefore $4^5 = 1{,}024$

Problem: $16^3 = ?$
Solution: Log 16 = 4; $4 \times 3 = 12$ = log 4,096
Therefore $16^3 = 4{,}096$

Problem: $\sqrt{1{,}024} = ?$
Solution: Log 1,024 = 10; $10 \div 2 = 5$ = log 32
Therefore $\sqrt{1{,}024} = 32$

Problem: $\sqrt[3]{4{,}096} = ?$
Solution: Log 4,096 = 12; $12 \div 3 = 4$ = log 16
Therefore $\sqrt[3]{4{,}096} = 16$

These problems could be easily solved by ordinary arithmetic, but suppose the problem is to get the fifth root of a number. Trial and error would be the only method of getting the answer by arithmetic. With logs it is simple, as evidenced by the following problem:

Problem: $\sqrt[5]{1{,}024} = ?$
Solution: Log 1,024 = 10; $10 \div 5 = 2$ = log 4
Therefore $\sqrt[5]{1{,}024} = 4$
Check: $4 \times 4 \times 4 \times 4 \times 4 = 1{,}024$

Problems involving fractional exponents cannot be handled by ordinary arithmetic except in special cases.

These are easily solved by using logs. For example·

Problem: $1{,}024^{0.6} = ?$

Solution: Log 1,024 = 10; $10 \times 0.6 = 6 =$ log 64

Therefore $1{,}024^{0.6} = 64$

Problem: $512^{\frac{4}{9}} = ?$

Solution: Log 512 = 9; $9 \times \quad = 12 =$ log 4,096

Therefore $512^{\frac{4}{9}} = 4{,}096$

Now the reader has probably noticed that the log table we have been using is a "skeleton" table omitting many numbers. All the gaps can be filled in, but the process is much more difficult than that by which the original table was made. A mathematician would call this particular table a "table of logarithms to the base 2" because each log in the lower line is 2 times the one before. Any other number could be used.

For reasons that will become evident as we go along, the most common "base" for logs is 10. The following is a skeleton table to the base 10:

Log	0	1	2	3	4	5			
Number	1	10	100	1,000	10,000	100,000			
				6		7		8	etc.
			1,000,000	10,000,000		100,000,000			etc.

Like the first table, this starts with zero as the log of 1, but each successive number is ten times the one before. The use of this table is illustrated by the following problems:

Problem in multiplication: $100 \times 10{,}000 = ?$

Solution:	Number	Log
	100	2
	$\times$ 10,000	+ 4
	1,000,000	6
	(product)	(sum)

Therefore $100 \times 10{,}000 = 1{,}000{,}000$

Problem in division: $100{,}000{,}000 \div 10{,}000 = ?$

	Number	Log
	100,000,000	8
	$\div$ 10,000	− 4
	10,000	4
	(quotient)	(difference)

Therefore $100{,}000{,}000 \div 10{,}000 = 10{,}000$

Problem in powers: $100^3 = ?$

Solution: Log 100 = 2; $2 \times 3 = 6 =$ log 1,000,000

Therefore $100^3 = 1{,}000{,}000$

Problem in powers: $100{,}000^{.6} = ?$

Solution: Log 100,000 = 5; $5 \times .6 = 3 =$ log 1,000

Therefore $100{,}000^{.6} = 1{,}000$

	0	1	2	3	4	5	6	7	8	9
1.0	0.0000	0043	0086	0128	0170	0212	0253	0294	0334	0374
1.1	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755
1.2	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106
1.3	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430
1.4	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732
1.5	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014
1.6	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279
1.7	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529
1.8	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765
1.9	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989
2.0	0.3010	3032	3054	3075	3096	3118	3139	3160	3181	3201
2.1	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404
2.2	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598
2.3	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784
2.4	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962
2.5	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133
2.6	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298
2.7	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456
2.8	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609
2.9	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757
3.0	0.4771	4786	4800	4814	4829	4843	4857	4871	4886	4900
3.1	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038
3.2	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172
3.3	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302
3.4	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428
3.5	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551
3.6	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670
3.7	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786
3.8	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899
3.9	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010
4.0	0.6021	6031	6042	6053	6064	6075	6085	6096	6107	6117
4.1	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222
4.2	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325
4.3	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425
4.4	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522
4.5	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618
4.6	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712
4.7	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803
4.8	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893
4.9	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981
5.0	0.6990	6998	7007	7016	7024	7033	7042	7050	7059	7067
5.1	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152
5.2	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235
5.3	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316
5.4	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396
5.5	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474
5.6	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551
5.7	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627
5.8	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701
5.9	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774
6.0	0.7782	7789	7796	7803	7810	7818	7825	7832	7839	7846
6.1	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917
6.2	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987
6.3	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055
6.4	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122
6.5	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189
6.6	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254
6.7	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319
6.8	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382
6.9	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445
7.0	0.8451	8457	8463	8470	8476	8482	8488	8494	8500	8506
7.1	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567
7.2	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627
7.3	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686
7.4	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745
7.5	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802
7.6	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859
7.7	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915
7.8	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971
7.9	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025
8.0	0.9031	9036	9042	9047	9053	9058	9063	9069	9074	9079
8.1	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133
8.2	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186
8.3	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238
8.4	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289
8.5	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340
8.6	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390
8.7	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440
8.8	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489
8.9	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538
9.0	0.9542	9547	9552	9557	9562	9566	9571	9576	9581	9586
9.1	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633
9.2	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680
9.3	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727
9.4	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773
9.5	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818
9.6	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863
9.7	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908
9.8	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952
9.9	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996

TABLE I. COMMON LOGARITHMS (BASE 10)

Problem in powers: $100{,}000^{\frac{7}{5}} = ?$

Solution: Log $100{,}000 = 5$; $5 \times \frac{7}{5} = 7 = \log 10{,}000{,}000$

Therefore $100{,}000^{\frac{7}{5}} = 10{,}000{,}000$

Problem in roots: $\sqrt[6]{1{,}000{,}000} = ?$

Solution: Log $1{,}000{,}000 = 6$; $6 \div 6 = 1 = \log 10$

Therefore $\sqrt[6]{1{,}000{,}000} = 10$

Although it serves perfectly to illustrate the principles, the skeleton table is of little practical use, because the few problems it can solve can all be done as easily without it. To fill in the gaps is not so simple a process as it was to lay out the numbers shown, but this work has already been done by the mathematician and need not bother the engineer. Table I gives the logs to the base 10, or "common logarithms," of all numbers from 1 to 10 by hundredths. The logs are carried to four decimal places, which is close enough for most engineering work. Where greater precision is required, longer tables giving five or more decimal places can be obtained.

N.	0	1	2	3	4	5	6	7	8	9	P. P.	
1850	267 1717	1952	2187	2421	2656	2891	3126	3360	3595	3830		
51	4064	4299	4533	4768	5003	5237	5472	5706	5941	6175		
52	6410	6644	6879	7113	7348	7582	7817	8051	8285	8520		
53	8754	8989	9223	9457	9692	9926	0160	0394	0629	0863	235	234
54	268 1097	1332	1566	1800	2034	2268	2503	2737	2971	3205	1 23.5	23.4
55	3439	3673	3907	4141	4376	4610	4844	5078	5312	5546	2 47.0	46.8
56	5780	6014	6248	6482	6716	6950	7183	7417	7651	7885	3 70.5	70.2
57	8119	8353	8587	8821	9054	9288	9522	9756	9990	0223	4 94.0	93.6
58	269 0457	0691	0925	1158	1392	1626	1859	2093	2327	2560	5 117.5	117.0
59	2794	3028	3261	3495	3728	3962	4195	4429	4662	4896	6 141.0	140.4
1860	5129	5363	5596	5830	6063	6297	6530	6764	6997	7230	7 164.5	163.8
61	7464	7697	7930	8164	8397	8630	8864	9097	9330	9564	8 188.0	187.2
62	9797	0030	0263	0496	0730	0963	1196	1429	1662	1895	9 211.5	210.6
63	270 2129	2362	2595	2828	3061	3294	3527	3760	3993	4226		
64	4459	4692	4925	5158	5391	5624	5857	6090	6323	6555		
65	6788	7021	7254	7487	7720	7953	8185	8418	8651	8884	233	232
66	9116	9349	9582	9815	0047	0280	0513	0745	0978	1211	1 23.3	23.2
67	271 1443	1676	1908	2141	2374	2606	2839	3071	3304	3536	2 46.6	46.4
68	3769	4001	4234	4466	4699	4931	5163	5396	5628	5861	3 69.9	69.6
	6001	6325	6558	6790	7022	7255	7487	7719	7952			

FIG. 1. PORTION OF A SEVEN-PLACE TABLE OF LOGARITHMS

From Table I it is evident that log 3.73 = 0.5717 and log 3.74 = 0.5729. If we want to get the log of 3.736 it is necessary to "interpolate." Since 3.736 is .6 of the distance from 3.73 to 3.74, its log should come .6 of the distance from 0.5717 to 0.5729. The difference between these two logs is 0.0012, and .6 of this is 0.0007 (to four decimal places). Adding this to 0.5717 gives 0.5724, which is the required log of 3.736.

A similar process is used to get the *number* when the log falls between two logs of the table. Suppose it is desired to find what number has a log of 0.8339. This log lies between the values 0.8338 and 0.8344, which correspond to the numbers 6.82 and 6.83 respectively. Hence the desired number lies between 6.82 and 6.83, and exceeds the smaller of these by the same fraction of the difference as the given log exceeds the smaller log in the table. The given log is greater than the smaller one by 1/6 of the difference, so the desired number is $6.82 + 1/6 \times 0.01 = 6.82 + .002 = 6.822$.

In everyday work it will often happen that this "interpolation" will be unnecessary, because it will be close enough for the work at hand to read to the nearest figure given in the table.

The next question that arises is what to do when the number is greater than 10. For example, what is the log of 25.3? First find the log of 2.53, which is 0.4031. The log of 25.3 will then be 1.4031. That of 253. will be 2.4031, that of 2530. will be 3.4031 and so on. It is evident that the part of the log after the decimal point is not affected by the location of the decimal point in the number, but that the part of the log before the decimal point is a number one less than the number of figures before the decimal point in the number. So the log of 3.41 is 0.5328 while that of 3,410,000. is 6.5328. The case where the number is less than 1 will be treated later.

We now have a practical table of logarithms and know how to "read" it. The rules for multiplication, division, etc. have already been illustrated, and apply here without change. For convenience they are summarized in Table II.

The following examples illustrate the use of these rules and Table I in the solution of various types of problems:

Problem: $242 \times 865 = ?$

Solution:

Number	Log
242	2.3838
$\times$ 865	+ 2.9370
209,300 (product[1])	5.3208 (sum)

Therefore $242 \times 865 = 209{,}300$

Problem: $24.2 \div 3.65 = ?$

Solution:

Number	Log
24.2	1.3838
$\div$ 3.65	− 0.5623
6.630 (quotient)	0.8215 (difference)

Therefore $24.2 \div 3.65 = 6.630$

Problem: $(66.2)^2 = ?$

Solution: Log 66.2 = 1.8209; $1.8209 \times 2 = 3.6418 = \log 4{,}383$

Therefore $(66.2)^2 = 4{,}383$

The problems given so far have been so simple that one would not ordinarily use logs to solve them. The following examples show where logs can be used to great advantage:

Problem in cube root: $\sqrt[3]{891} = ?$

Solution: Log 891 = 2.9499; $2.9499 \div 3 = 0.9833 = \log 9.622$

Therefore $\sqrt[3]{891} = 9.622$

Problem in fractional powers:[2] $(6.4)^{1.2} = ?$

Solution: Log 6.4 = 0.8062; $0.8062 \times 1.2 = 0.9674 = \log 9.277$

Therefore $(6.4)^{1.2} = 9.277$

It has been shown how Table I, giving the logs of numbers from 1 to 10, can be used to get the log of any number above 10. But what about numbers less than one? What for example, would be the log of .00326? The answer is 0.5132 − 3.

Here the part of the log after the decimal point (.5132) was obtained in the usual manner, by disregarding the decimal point in the number, but the part before the point (− 3.) is a minus quantity (written separately to avoid confusion). It is a number

[1] By arithmetic, the exact answer is seen to be 209,330, but the four-place logs we are here using can give the answer accurately only to the fourth figure.

[2] Problems like this occur in figuring the expansion of steam or gas in an engine cylinder. (See article on page 378, *Power*, March 7, 1922.)

equal to the number of decimal places the point would have to be moved in the number to make it read 3.26 as given in the table. Similarly, log .326 = 0.5132 — 1., log .0326 = 0.5132 — 2. and log .0000326 = 0.5132 — 5.

The following problem illustrates the use of this sort of log:

Problem: $\sqrt[3]{0.000623} = ?$

Solution: Log 0.000623 = 0.7945 — 4.; (0.7945 — 4.) ÷ 3 = 0.2648 — 1.3333 = 0.2648 + 0.6666 — 2. = 0.9314 — 2. = log 0.08538

Therefore $\sqrt[3]{.000623} = 0.08538$

This is a good place to summarize, in the form of a rule, what has been said about decimal points:

RULE FOR DECIMAL POINTS

A log consists of two parts — a whole number and a decimal. The log table ordinarily gives only the decimal part of the log. The value of the decimal part of the log is not changed by shifting the decimal point of the number. The "whole number" part of the log is equal to the number of places the actual decimal point of the number would have to be shifted to give a number between 1 and 10. If this shift is to the left that part of the log is plus, if to the right it is minus.

Table I is a "four-place table of logarithms." Sometimes it is desirable to use a table with more places for computations requiring unusual accuracy. Such tables often run to several hundred pages, but books containing them are printed by the thousand and can be obtained at low prices. The successive numbers in such tables differ so little that it is close enough, for most engineering work, to use the nearest printed values. Extreme accuracy is obtained by "interpolating," and tables of "proportional parts" are supplied to make this as easy as possible.

TABLE II. ABBREVIATED RULES FOR USE OF LOGARITHMS

When problem is one of	It becomes, by the aid of logs, one of	The abbreviated rule is
Multiplication	Addition	Add the logs of the two numbers to get the log of the product
Division	Subtraction	Take the difference between the logs of the two numbers to get the log of the quotient.
Powers	Multiplication	Multiply the log of the root by the exponent to get the log of the power.
Roots	Division	Divide the log of the power by the exponent to get the log of the root.
Addition.....	Can't use logs	.....
Subtraction	Can't use logs	.....

Table II reproduces the top of one page from such a book. Suppose we want the log of 185.723. For the present, pay no attention to the decimal point in the number. Note also that the table gives only the part of the log *after the decimal point.* The log of 18,572 is 0.2688587 (4th column and 9th line). That of 18,573 is 0.2688821. The difference in the last three places of these logs is 234. Now note the space at the right headed *"P.P."* (proportional part). In it is a column headed 234. Opposite 3 it reads 70.2, which means that three tenths of 234 is 70.2. Don't bother with the .2. Add 70 to the right end of the first logarithm as follows:

$$\begin{array}{r} 0.2688587 \\ +\ 70 \\ \hline 0.2688657 \end{array}$$

Taking into account the position of the decimal point in the number, the desired log of 185.723 is 2.2688657.

Now suppose the log is 1.2677837 and it is desired to find the number. The number must lie between 18,526 and 18,527, as follows:

Number	Log	
18,526.	1.2677817	*a*
?	1.2677837	*b*
18,527.	1.2678051	*c*

The difference between the right-hand ends of *a* and *b* is 20, and between *a* and *c* 234. Now look in the *"P.P."* section and the 234 column. The nearest figure to 20 is 23.4 opposite 1. So add 1 beyond the last place of 18.526, giving 18.5261 as the number whose log is 1.2677837.

This "interpolation" is the only thing about logarithms taking much time. Usually this can be avoided.

Voltage Regulation of Rotary Converters

Since a change in the field strength of a rotary converter does not alter the direct-current voltage, compounding the field would not affect the direct-current voltage, which would therefore drop with the load. The only way to keep the direct-current voltage constant at all loads is to change the alternating-current voltage. This may be accomplished by inserting separate reactance between the transformers and alternating-current side of the machine or by designing the transformers with the necessary reactance. If the field now be over-excited, the converter will take a leading current and cause a voltage rise through the reactance, so that the alternating voltage at the converter will increase with an increase of field. This increase of field may be brought about automatically by the use of a series field, and any degree of compounding may be obtained by proper reactances.

Another method of voltage regulation is to use a synchronous-booster-type converter. The synchronous booster is a synchronous generator of the revolving-armature type, keyed to the converter's armature shaft. The booster has the same number of poles and phases as the converter itself. It is connected directly in series with the converter on the alternating-current side, and its voltage either adds or subtracts from the voltage impressed on the converter, according to the direction of excitation.

An induction regulator may be used, which is an induction motor with a wound rotor, the rotor of which is blocked and capable of being turned to any position by means of gears. The regulator is placed between the converter and transformers. Its principle is that of a transformer with varying voltage ratio. In this way the alternating-current voltage may be changed to compensate for any change in direct-current voltage.

Voltage regulation by series reactance is cheaper than other methods and is used where a change in direct-current voltage of more than 10 per cent is not necessary. If, however, a close regulation of the direct-current voltage over a wide range is necessary, a synchronous booster should be employed. By the use of a synchronous booster, the voltage and power factor may be independently controlled, which is often desirable.

Hydro-electric development is progressing with particular rapidity in Spain, according to advices to the Department of Commerce. Within a few months there will be 150 important hydro-electric plants in operation in that country. Their combined output is 1,200,000 hp.

EDITORIALS

Waste and More Waste

THREE things characterize our fuel resources—their extensiveness, the tremendous volume used each year and the enormity of the waste. The wastes are going on not only in utilization, but also in production and transportation. Of the fuel used for power purposes probably on an average not over eight or ten per cent is available for distribution from the power plant; the remainder is lost in the form of heat in the flue gases, circulating water, exhaust to the atmosphere, steam leaks, etc. In mining operations, of the total coal in the mines it has been estimated that an average of only about sixty-six per cent is taken out. The almost criminal waste of our natural gas is too well known to require comment, and the exhaustion of this fuel is fast approaching.

Even in the use of crude oil and its distillates there are enormous wastes. A recent investigation has shown that over seventy-two million gallons of gasoline is being lost annually, owing to evaporation from uninsulated tanks. Assuming a market price for this product of twenty cents a gallon, the value of this loss is more than fourteen million dollars, or the equivalent of over fifteen per cent on ninety million dollars investment, which looks like a real inducement to make a strenuous effort to save this waste. The use of gasoline is increasing, and the oil companies are finding it more difficult each year to meet the demands. Preventing the evaporation loss is one way to increase the supply materially without having to increase the output, besides conserving one of our most valuable resources.

The Effect of Excess Air on Flue-Gas Temperature

ONE would naturally suppose that excess air, reducing as it does the furnace temperature and the temperature of the gaseous products of combustion, would result in a lowering of the flue-gas temperature.

As a matter of fact this is not always nor even generally so. The lowering of the furnace temperature results in a considerable reduction of the amount of radiant heat absorbed by the boiler, a large proportion of that generated when the furnace temperature is high. The heat not so absorbed is diffused in a larger volume of cooler gas which, with the lessened temperature difference and greater velocity, is less readily taken up by the heating surface.

Increasing importance is being attached to the part that radiant heat plays in boiler efficiency. In the agitation for higher settings and greater furnace volumes it was often argued that as long as the fuel was completely burned it would generate a certain number of heat units anyway, and, radiation neglected, all of these had to go through the boiler even if the furnace were completely detached. A piece of heating surface, however, that can "see" the fire, will absorb directly a lot of heat by radiation. The heat rays are pounded into it at a high temperature through any interposing film of cooler gas that may exist. The flowing gases are cooler than the body of the fire and the heated brickwork. When they strike the boiler surface, they are chilled and there is a film of cooler gas in immediate contact with the surface through which the heat in the surrounding gas has to struggle. There is always a considerable temperature gradient at the fire surface of a tube or sheet when heat is absorbed by convection, against which radiant heat does not have to strive. It is better, therefore, while providing ample furnace volume, to so design the furnace, with respect to the relation of the fire to the heating surface, that as much as possible of the heat generated may be immediately absorbed by radiation and not take chances on any more of it than can be helped being absorbed by the tortuous and complicated processes of convection.

Selecting the Operator

THE operator appears to be the center of discussion in the power plant today, and ways and means are being devised to eliminate him in part if not altogether. He is frequently referred to as the troublesome operator, but is he responsible for all the troubles that are laid at his door? If no more attention were paid to the selection of automatic equipment and keeping it tuned up than is paid in many cases to the selection of operators, the former would lose its present good reputation. Where operators have been carefully chosen and trained, they have shown that they can be depended upon to do the right thing in emergencies and to be on the job to get a machine or the station back into service in the least possible time in case of trouble.

The present tendency toward the automatic operation of substations and small water-power plants is justified in many cases by economic and engineering considerations. However, the human element must still be taken into account, and unless those to whom the inspection and maintenance of these plants are intrusted are well suited for the work, trouble will result. Consequently, automatic control of power-plant equipment does not eliminate the problem of a selected and trained personnel, which, if anything, demands even more serious attention, though the number of employees involved may be materially reduced.

Unless the man chosen to be trained as an operator is suited to the work, he will never become proficient. The qualified operator must be of the type that can be depended upon to look after details when everything is running smoothly and to think quickly and do the correct thing in an emergency.

A mistake made in handling large power-plant equipment may result in thousands of dollars in damage, not to mention the inconvenience of having the equipment out of commission or the interruption to service. Experience has shown that by proper training of the operating force most of these losses can be prevented. If an emergency arises that an automatic control fails to take care of, effort is made to develop some device that will prevent this from occurring. Why not, then,

give the human operator the same consideration, by proper instruction. When this is done he, if intelligently chosen, will not be the troublesome operator that he has been characterized. Undoubtedly, the conditions in many plants could be improved by making the control more automatic than at present, but it requires good judgment in doing this as there may be such a thing as too much automatic control and not enough operator. An intelligent selection of each is one of the largest factors in a reliable power service.

High- or Low-Pressure Steam Generation for Process Work

AS EVIDENCED by the discussion at a recent meeting of engineers, the average member of the profession is still somewhat at sea in regard to the principles affecting the choice between the high- and low-pressure generation of process steam. The same remark applies to the relative merits of engines and reducing valves as a means of lowering the generated pressure to that of the process.

Apropos of this, Dr. Edgar Buckingham, of the Bureau of Standards, in an instructive paper recently published in *Mechanical Engineering*, tackled these old problems from the viewpoint of the physicist. The subject of his inquiry might be stated as follows: "What are the relative advantages and disadvantages of (1) generating process steam directly at the pressure at which it is to be used, (2) generating it at high pressure and then passing it through a reducing valve near the process, and (3) generating it at high pressure and passing it through an engine exhausting to the process?"

The conclusions reached by the author are, in the main, the same old conclusions reached by most engineers who have studied the subject. Almost everybody would agree with him that—assuming equal boiler efficiencies and equal transmission losses—the same percentage of the heat of the coal is given up to the process whether the steam is generated at low pressure, or generated at high pressure and then passed through a reducing valve. Many would disagree with some of his other conclusions.

Laying aside for the moment the case where the pressure drop occurs in an engine or turbine instead of in a reducing valve, it is worth while to consider Mr. Buckingham's statement, "It would seem, in view of the foregoing reasoning, that unless the transmission line is very short, a properly designed high-pressure plant may be decidedly more economical in operation than a low-pressure one." In this he referred particularly to the problem of a vulcanizer using steam at forty-five pounds gage, where the steam could be generated at that pressure or at one hundred ninety pounds.

His conclusion was based on the fact that a much smaller pipe could be used with the high-pressure steam by allowing a large pressure drop in the line, thus effecting a considerable reduction in the radiation loss in spite of the higher temperature. No account, however, was taken of the probable increase in boiler efficiency with a reduction in pressure. For the same boiler and the same heat output the flue temperature, and hence the flue loss, should be less at the lower pressure. Although the resulting increase in output per pound of fuel would amount to only three or four per cent, it would probably more than offset the difference between the heat losses from well-insulated high- and low-pressure lines of average length. This would seem to leave the thermal advantage with the low-pressure installation, unless some third factor has been overlooked.

Suppose, for example, that steam at forty-five pounds gage is passed through a four-inch line with a velocity of six thousand feet per minute. The total weight per hour is then about 4,400 lb., and the total available heat around 4,000,000 B.t.u. If well insulated, one hundred feet of this pipe should not lose more than 20,000 B.t.u. per hour—about one-half per cent of the available heat in the steam. So, if we assume that the available heat in the steam produced by one pound of coal in the high-pressure boiler is three per cent less than for the low-pressure boiler, and if we entirely neglect the considerable heat loss from the high-pressure line, the line will have to be about six hundred feet long before the fuel consumption with the low-pressure installation will equal that with the high.

For a larger main carrying proportionally more steam at the same pressure and velocity, the result would be even more favorable to the low-pressure installation. Other matters not considered are the increased safety and simplicity of low-pressure operation and the possibility of using a less expensive boiler. On the other hand, the cost of piping and covering should be less for the high-pressure installation.

The preceding comparison is of interest only where there is no demand for high-pressure steam for the production of power. By using an engine exhausting to the process, power can be generated for but little more than 2,545 B.t.u. (from the steam) per horsepower-hour. Assume that, on account of bearing friction and other losses not returned to the exhaust steam, the engine takes out as much as 3,000 B.t.u. per developed horsepower. With 13,500 B.t.u. coal and a boiler efficiency of sixty-five per cent, this means that about one-third of a pound of coal per horsepower-hour is chargeable to power. Even with coal at ten dollars a ton this gives a *fuel* cost of less than one-fifth of a cent per horsepower-hour.

Another way to put it is to say that an engine, whether of high or low thermal efficiency, will exhaust to the process all the heat it receives minus the heat equivalent of about three pounds of steam per developed horsepower-hour. So the oft-repeated statement that "power may be obtained for nothing from process steam" is not far from the truth as far as fuel costs are concerned.

Those who remember and used to enjoy the annual "Mechanical Exhibition" of the American Institute will find in the Power Show, to be held in the Grand Central Palace, Dec. 7 to 13, a chance to renew their interest and to compare the power appliances which today have attained sufficient importance to have an exhibition of their own with those which were but incidental features of the older expositions.

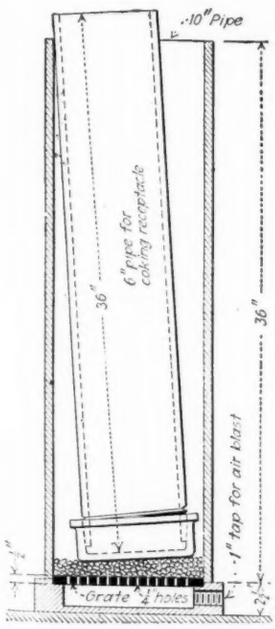
There is danger in generalizing as a result of one's individual experience and observation unless backed up by sufficient investigation. This is particularly noticeable in the many fallacious statements heard during discussions at engineering society meetings; and the more prominent the man making the assertion, the greater the danger that it will be accepted as fact.

PRACTICAL IDEAS from PRACTICAL MEN

A Simple Practical Coal-Testing Apparatus

The description herewith of a simple coal-testing apparatus will appeal to many engineers as at least a practical solution of a difficult problem.

Chemical analyses, while interesting and useful, are not a criterion of the performance of any coal in a furnace. Besides, an analysis of each car of coal, to check deliveries, is somewhat expensive for small plants. Evaporative tests are conclusive, but expensive to carry out in such a way that results can be depended upon. An inaccurate test is worse than useless.



SIMPLE APPARATUS FOR TESTING COAL UNDER FURNACE CONDITIONS

The practical engineer wants to know three things about his coal: First, the percentage of volatile matter; second, the percentage of refuse; third, the percentage of clinker. The chemical analysis does not show what proportion of each of these constituents results from combustion in the furnace. To burn a sample of coal under laboratory conditions and to burn a sample under furnace conditions are quite different things. In order to judge the performance of coal in a furnace, the furnace conditions must be duplicated on a small scale. In order to make the test herein described an air blast must be available. This is usually not difficult to obtain in any engine room.

Take a piece of 10-in. steel pipe about 36 in. long. Have a cast-iron base made to form an ashpit and a support for the pipe. Make a grate by cutting out a circular piece of steel plate about $\frac{3}{8}$-in. or $\frac{1}{2}$-in. thick and drill full of $\frac{1}{4}$-in. holes. The coal receptacle is made by screwing a 6-in. pipe 36 in. long into a standard 6-in. cap and turning the cap down in the lathe to a uniform thickness of $\frac{3}{8}$ in. or $\frac{1}{2}$ in.

To test a sample of coal, weigh out an ordinary coal bucket about half full or, say, take 10 lb. net of coal, dry it on top of the boiler in a pan and weigh it again, then empty it into the coal receptacle. The loss in weight divided by the original weight of the coal gives the percentage of moisture.

Now build a coke fire in the 10-in. pipe, turn on the blast to make a hot fire, and place the receptacle of coal into the 10-in. pipe, allowing it to rest on the bed of coke. Cover the top with an oversize or loose-fitting cap. When the coal in the 6-in. pipe is thoroughly "coked," empty it back into the bucket and weigh. The loss is the weight of the volatile gases.

Now empty the 10-in. pipe and build a new fire on the grate with a little charcoal. Pour the coke previously made into the receptacle (leave uncovered) and burn by means of a strong blast until it is completely burned out. When cool, weigh the refuse in the same bucket as before. The weight divided by the original weight of coal gives the percentage of refuse.

Now pour the refuse out on the floor and pick out by hand the fusible matter or clinker and weigh this. The weight divided by the original weight of coal gives the percentage of clinker.

After burning a few samples of coal in this way and watching their performance in the furnace under the boilers, it will be possible to judge accurately as to the quality of coal being shipped, and to prophesy what might be expected from a coal of which a carload sample is not available for an evaporative test. It is not out of the question to purchase coal on a test of this kind, making the payments on the proportion of ash and clinker shown rather than on the B.t.u. basis.

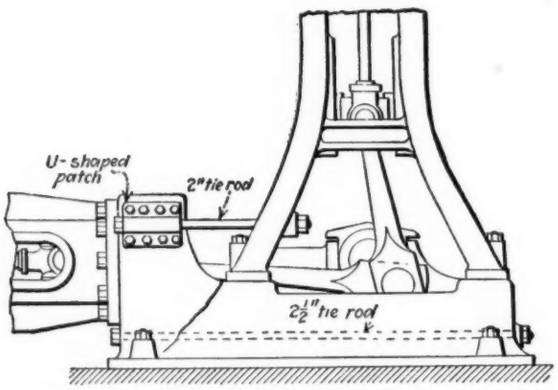
It is doubtful if coal purchasers pay enough attention to the percentage of ash in the coal they buy and to the quality of the coal shipped after the first few carloads subsequent to the acceptance of a coal contract. The difference between 8 per cent and 12 per cent ash on a 1,000-ton per year contract, considering the two coals at the same price, say $6 a ton, makes a difference of $300 a year in the cost and even more than this if the coal cost exceeded $6 a ton. This amounts to 5 per cent of the original cost of the coal, which is an item worth saving. The test described will enable the engineer to choose between several coals and detect quickly any change in the kind or quality shipped. Furthermore, any operating engineer or fireman can make practical coal tests right outside his own boiler room.

Grand Rapids, Mich. H. GEORGE D. NUTTING.

Repair of a Cracked Engine Bedplate

Owing to a slug of water passing into the cylinder along with the steam, the bedplate of a horizontal engine driving a vertical ammonia compressor was cracked as shown in the cut. The damage was repaired by drilling two $2\frac{5}{8}$-in. holes in each end of the bedplate and clamping it together with $2\frac{1}{2}$-in. tierods. The rods were heated to a dull red for about 18 in. in the middle of their lengths before they were inserted. Washers, one of which was beveled on one face to conform to the taper at the outer end of the frame, were slipped over the rods, and the nuts were pulled up tight. As the rods cooled, the ends of the bedplate were drawn together until the fracture was almost invisible.

The machine was then put in service, but after it had been run for a day or two, it became apparent that the staying afforded by the through-rods was not sufficient. It was then decided to tie the engine-bed to the A-frame supporting the compressor cylinder. Accordingly, two $2\frac{1}{16}$-in. holes were drilled in the A-frame and a U-shaped patch was fastened with $1\frac{1}{2}$-in. capscrews to each side of the bed forming the guide yoke. The U-patches were then clamped to the A-frame with



METHOD OF REPAIRING BEDPLATE BY MEANS OF TIERODS

2-in. tierods. These bolts were also heated in the middle to a dull red before putting them in place.

This job of patching was at first intended to be only temporary, as it was planned to replace the broken bedplate with a new one at the first opportunity. But the repair job proved to be so substantial that all thought of replacing the bedplate was finally abandoned.

St. Louis, Mo. A. J. DIXON.

Automatic Boiler Regulation

If the load were perfectly steady and if the coal varied neither in heating value, volatile, ash, nor in fineness, it would be an easy matter to make adjustments for maximum efficiency, hand out some rigid instructions and let things run. However, since the demand for steam and the quality of the coal change, the draft, rate of coal feed, rate of boiler feed, temperature of feed (steam supply to heater), all must be regulated if efficiency is to be maintained.

It is the contention of the writer that these adjustments can be made far better with the regulating devices now on the market than by the individual firemen. Possible exceptions may be the highly trained men in the large central stations, but even they will obtain better results if given the assistance of good automatic equipment. A good feed-water regulator, properly installed and adjusted, will control the boiler feed much better than a man could ever do it, and likewise with many other devices.

If a boiler is equipped with a modern feed-water regulator that varies the rate of feed with the change of water level, within limits, it will operate in two ways to smooth out any sudden changes in steam demand. As the steam pressure decreases and the fire is built up,

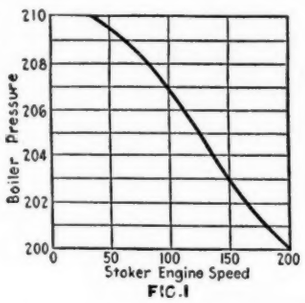


FIG. 1

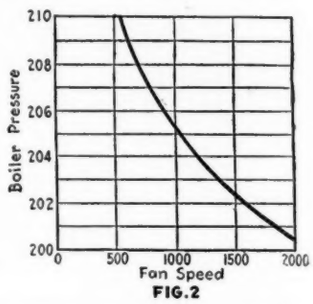


FIG. 2

FIGS. 1 AND 2—CHARACTERISTIC CURVES OBTAINED WITH AUTOMATIC REGULATION OF STOKER AND FAN SPEEDS

the water level in the drums will tend to rise owing to the presence of more steam in the tubes. The regulator will then decrease the rate of feed for a short time, which enables the boiler to deliver more steam to the line, thus helping to maintain the pressure.

The effect of variation of feed control is readily seen from the following example: Suppose a 1,000-sq.ft. boiler to be delivering 3,200 lb. of steam per hour at 160 lb. gage, feed at 180 deg. F. Now if there is no change in furnace conditions and the rate of feed be suddenly increased to twice that necessary, or 6,400 lb., the boiler will deliver at the rate of 2,467 lb. of steam per hour to the line. If the feed then be suddenly shut off when the level is high, the boiler will steam at the rate of 3,940 lb. per hour, or 20 per cent more than

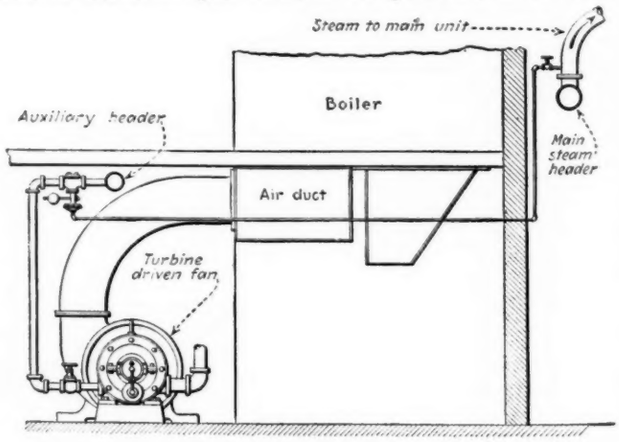


FIG. 3—PRESSURE CONNECTION OF FAN CONTROL CONNECTED CLOSE TO MAIN UNIT

when fed steadily. So it is readily seen, as many flow meters have shown, that the amount of steam a boiler delivers may be varied 40 per cent or more simply by varying the rate of feed. Add to this the condition that the heater is supplied only with enough steam from auxiliaries to heat the average amount of feed, the feed water will then get considerably colder during periods of excessive demand, and the variation in steam delivered by the boiler may be considerably greater.

The first sign of increased steam demand is usually a drop in steam pressure. The fuel feed and air supply should at once be speeded up, but how is this best accomplished? When an underfeed stoker is speeded up, it at once increases the rate of combustion owing to the increased slicing of the fire by incoming coal and the secondary rams, grates or push blocks. The chain grate is somewhat slower unless sliced by hand. If the air

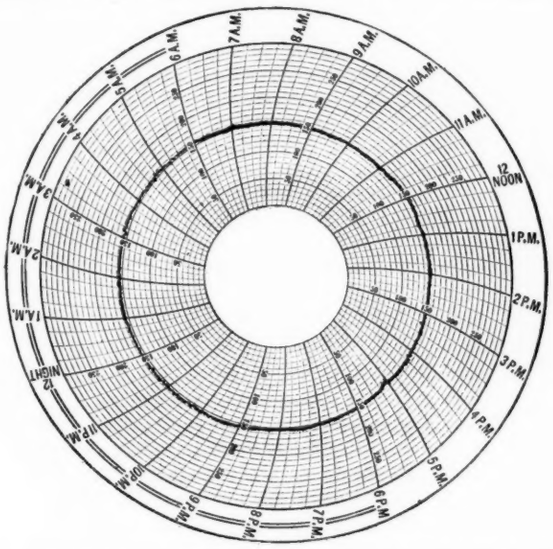


FIG. 4—RECORD OF STEAM PRESSURE OBTAINED WITH AUTOMATIC REGULATOR

supply is suddenly increased in either case, too much air will pass through the furnace until the fuel bed is built up. Here is an advantage of zone air control because the air can be quickly increased in the first zone and followed by zones 2 and 3, etc., when the fuel-bed thickness warrants.

Good results have been obtained in the case of turbine-driven fan and engine-driven stoker where each is equipped with a regulating valve which increases or decreases the steam supply with the decrease or increase of steam pressure. The regulating valves are adjusted to take full advantage of the greatest permissible variation of steam pressure, and the openings are adjusted so as to give characteristic curves shown in Figs. 1 and 2.

Getting the proper characteristics is largely a matter of cut and try. A common fault is that the regulating valves usually supplied are too large for the work. It may be necessary to change the valves entirely or make special parts. Springs may have to be added or changed.

An important point comes up here. It sometimes requires weeks of experimenting to get the right condition. The manufacturer of, say, a feed-water regulator does not usually include the cost of much service in his price. The engineer cannot adopt a "Well, let's-see-you-make-it-work" attitude if he expects to get the best results. The operation of a feed-water regulator may depend on the proper functioning of other equipment and similarily with other devices. By systematic experimenting, the engineer may find an adjustment or change not given in the manufacturer's directions that may give the best results for his particular plant.

When making adjustments of the fan control, it should be remembered that the air pressure will vary about as the square of the speed of the fan. If the fuel bed had a constant resistance like an orifice, the air supply would vary as the square root of the pressure or directly as the speed of the fan. But the fuel-bed resistance changes, so this must be compensated for by increased fan speed in order to provide the proper air supply. In order to take care of heavy peak loads of short duration, the ratio of air to fuel may be increased to get more burning capacity.

A kink that has worked well in some cases is to run the pressure connection of the regulating valve or control to some point near the main unit as shown in Fig. 3. This makes the control sensitive to *rate of flow* as well as steam pressure if there is appreciable pressure loss in the piping, as is usually the case. Then, when the main unit opens up the governing valves to take care of increased load, the regulator instantly responds and does not wait for the steam pressure at the boilers to start down. If the pressure drop between boilers and turbine is great enough, 10 pounds or so at full load, the regulators can be adjusted to give increased boiler pressure at peak loads.

The preceding has reference to steam-driven auxiliaries, but the same methods apply to electrically driven apparatus. The compensating mechanism of the controller can be made to assume the functions of a cam which will give any desired speed of fan or stoker for a given steam pressure.

With the regulating apparatus working properly, good CO_2 can be maintained with an astonishingly small amount of attention on the part of the firemen. The charts of CO_2 and steam pressure shown herewith were taken from a plant where the firemen never touched the feed-water valves or the fan controls from one week

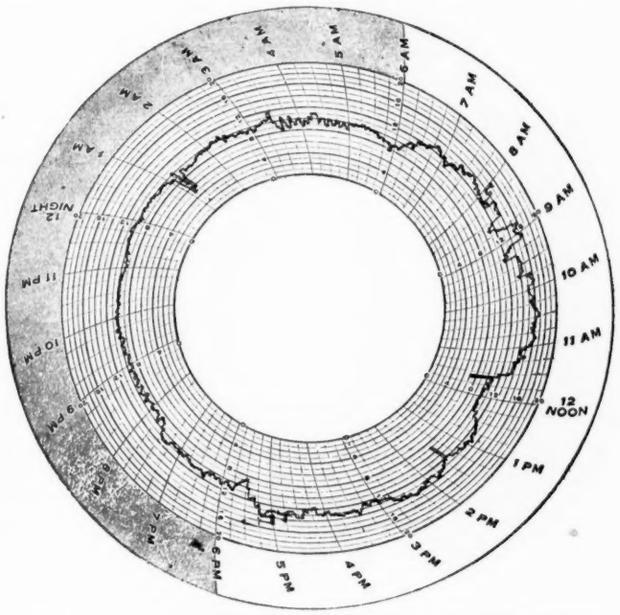
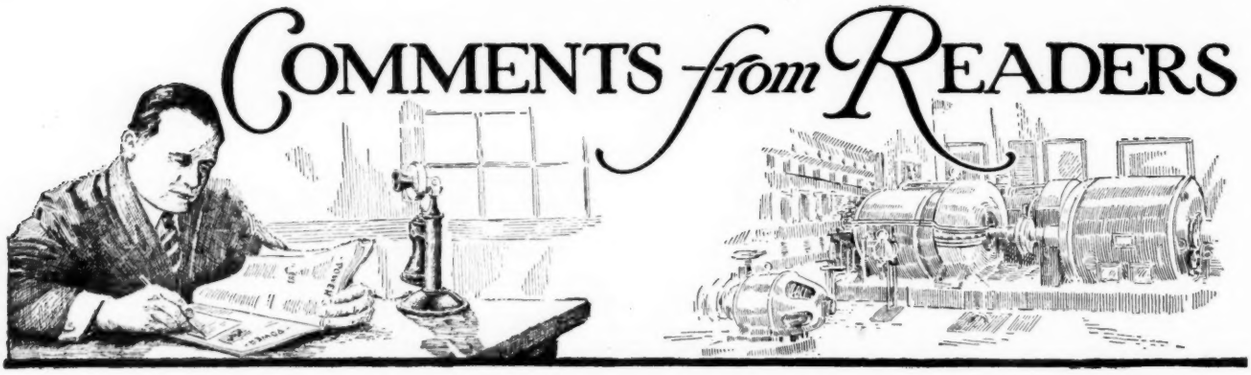


FIG. 5—CO_2 CHART SHOWS GOOD BOILER OPERATION

to the next. In this case the stokers are steam-actuated, the steam valves being belted to the fan shafts. The ratio of fan speed to stoker speed is adjustable, and this adjustment is made by the foreman. The fireman's principal duties are to weigh the coal and dump the ashes. This plant was thought to have a widely fluctuating load, and so the flow meters indicated until the controls were installed and adjusted. J. R. BELKNAP.

Lansing, Mich.



Large American Steam Engine

I notice in your issue of Sept. 26, 1922, an illustration and description of a 25,000-hp. vertical three-cylinder engine built in England. Few people know that E. D. Leavitt designed a vertical three-cylinder engine for the Bethlehem Steel Works a few years before he died. I think this engine is of about the same horsepower as the English engine, and it drives hydraulic pumps for forging machines. F. W. DEAN.

Boston, Mass.

Using a File on Bearings

Some time ago there was considerable discussion in *Power* over the assertion of an engineer who stated that he had trouble with a bearing persistently heating up, until he finally diagnosed the trouble as due to the shaft being too smooth. He then draw-filed it to roughen it slightly, and after that it ran perfectly cool and gave no further trouble.

Just how this eliminated the trouble was never clear to me until recently, when I discussed the subject with a turbine erector, who had met with a similar instance in his own experience. He ascribed the cause of the heating to a small hard spot or difference in the structure of the metal of the bearing. This allowed the shaft to bear only on a comparatively small area of the bearing and made lubrication difficult, but when the shaft was roughened slightly, this hard spot was worn away and the shaft bedded uniformly over the whole area of the bearing. This seems quite a plausible explanation of an otherwise puzzling occurrence.

Swathmore, Pa. H. D. FISHER.

Water Softening with Zeolites

In an article entitled "Softening Boiler-Feed Water with Zeolites," appearing in the Sept. 12 issue of *Power*, an interesting explanation of this method of water softening is given, but the following statements seem to the writer to be incorrect: (1) "The substances left in the water by this exchange are (sodium bicarbonate, etc.) in the same amounts as the bicarbonates, sulphates and chlorides originally present;" and (2) "As far as priming is concerned, the treated water is equivalent to the untreated, since the total weight of dissolved solids remains the same."

The assertions are not in accordance with the facts for the following reasons:

(1) It is not true that the total dissolved solids in the raw and treated waters are the same, since in every case where calcium or magnesium in salts in solution is replaced by sodium, the resulting sodium salts will weigh more than the original calcium or magnesium compounds. As a consequence the total dissolved solids will be higher than in the raw water. This is due to the fact that two atoms of sodium with an atomic weight of 23.0 are required to displace one atom of calcium (atomic weight 40.07) or an atom of magnesium (atomic weight 24.32). The difference in the quantity of dissolved solids in treated water and raw water is not great, but nevertheless there is a difference.

(2) The error in regard to quantity of total dissolved solids is here repeated, and it is not correct that the treated water is equivalent to the untreated in priming properties. Since the calcium and magnesium in the raw water are replaced by sodium, it is plainly evident that the resulting sodium salts, which are recognized as foaming salts, are much more liable to foam than the same calcium or magnesium compounds, when these salts are never even classified as possessing foaming properties. Sodium bicarbonate which is formed whenever bicarbonate or temporary hardness is present in the raw water, is one of the worst offenders in foaming. It is the quantity of alkali salts rather than the total solids which cause a water to foam.

The article is, as a whole, very interesting and instructive and, along with other articles on feed-water treatment to come, will be of great value to many readers of this magazine. PAUL F. HOOTS.

New Orleans, La.

[Mr. Hoots is strictly correct in his comments on the first statement. Yet the writer of the article was fully aware of these chemical relations. There is no difference of opinion as to the facts, the only difference is one of language. Mr. Hoots is using the word "equals" in the exact mathematical sense, whereas the writer uses it in the practical sense to mean "practically equal." We do not object when a carpenter says a piece of board is one inch thick, even though we know that an exact 1-in. board never existed outside of the imagination. The second comment, however, involves an actual difference in opinion. Most of the textbooks take the same position as does Mr. Hoots. Yet many engineers who have had extensive experience in this line take the view given in this article that the total solids are the determining elements, provided that the water is entirely free from suspended matter and oil. These engineers say that the common belief that sodium salts cause priming is due largely to experience with water containing oil or with the waters of the Southwest. In the latter case, they say, waters high in sodium salts, but low in scale-forming solids, cause much trouble from priming for the simple reason that they are allowed to reach high concentrations in the boiler.—Editor.]

What Size of Combustion Chamber Is Necessary with Fuel-Oil Burning?

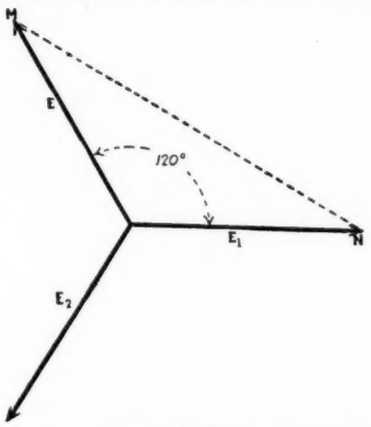
In reply to the question asked by Mr. Davies in the Sept. 26 issue, on the size of combustion chamber necessary with fuel-oil burning, I have found it good practice to allow 90 cu.ft. of combustion area for each 350 lb. of oil burned per hour.

For a fuel consumption of 1,500 lb. per hour this would give a combustion area of 386 cu.ft. Some authorities on combustion recommend 80 cu.ft. for each 350 lb. of fuel, but in my opinion this is not sufficient. As this is an important subject, I should like to see some further discussion in *Power*. L. B. SHIELDS.

Chicago, Ill.

Power of a Three-Phase Circuit

To many people the factor $\sqrt{3}$ as used in three-phase calculations has always been a mystery. In fact, many textbooks omit the simple reasoning by which this factor is obtained. For the benefit of some of your readers who may be interested and especially for



RELATION BETWEEN THE THREE VOLTAGES IN A THREE-PHASE CIRCUIT

S. D. H., who asked about this factor on page 431 of the Sept. 12 issue, the following explanation is given:

For example, consider the emf. relations in a star-connected armature winding as shown in the figure.

Here E, E_1 and E_2 represent the voltage generated per phase, while MN is the resultant of any two of these voltages. MN is therefore the voltage across any two terminals of the machine. The relation between MN and its two components is expressed by the formula:

$$\overline{MN}^2 = E^2 + E_1^2 - 2(E_1 E) \cos 120 \text{ deg.}$$

But as $E = E_1$

Then
$$\overline{MN}^2 = 2E^2 - 2E^2 \cos 120 \text{ deg.}$$
$$= 2E^2 - 2E^2(-\sin 30 \text{ deg.})$$
$$= 3E^2 \ (\text{since } \sin 30 \text{ deg.} = \tfrac{1}{2})$$

Therefore
$$MN = \sqrt{3E^2}$$
$$= E\sqrt{3}$$

In other words the voltage between any two terminals is equal to the voltage per phase multiplied by the $\sqrt{3}$. In the relations assumed in the foregoing, the current in the lines is identical with the current in the respective windings, therefore the apparent power is the product of this current by MN, which is itself the product of $E\sqrt{3}$.

A similar line of reasoning can be followed out in the relations of a delta-connected armature winding, wherein the voltage between terminals equals the voltage per phase, but where the current in the line equals the current per phase times the $\sqrt{3}$. Since this is so, the calculation of apparent power need not take into account the scheme of connections, as the result is the same in either case. L. M. SMITH.

Ensley, Ala.

Why the Consulting Engineer Should Design the Power Plant

In the letters by T. A. Marsh in the Sept. 19 issue and by Ignacio Izsak in the Oct. 3 issue on "Why the Consulting Engineer Should Design the Power Plant" the statements made are entirely sound. The smaller stations do not, in general, have within their organizations the correct talent for designing a station, but it often happens that the consulting engineer has been so many years engaged in design he has lost sight of many operating details. Almost any station operator, after a short time in a plant, can point out faults in design that will inevitably result in hazards to service and in increases in operating costs.

The type of man who should be employed as operator should be made dependent upon the opportunity for saving which will exist in the particular station that he is to operate. A station of 100,000-kw. capacity with an annual load factor of 50 per cent (based on the rated capacity) would have an annual output of 438,000,000 kw.-hr., and a saving of one-tenth of a mill per kilowatt-hour would amount to $43,800 per year. For $10,000 a year a man could be secured to operate this station who could do it enough better than a man procurable for $3,000 to effect a reduction in the cost per kilowatt-hour of 0.05 mill, or $21,900 per year, about three times the increase in salary. These figures may fairly be modified in direct proportion to the annual output, in applying the idea to other stations. This is not an argument in favor of paying $3,000 men $10,000 a year, but rather an argument against intrusting $10,000 jobs to $3,000 men.

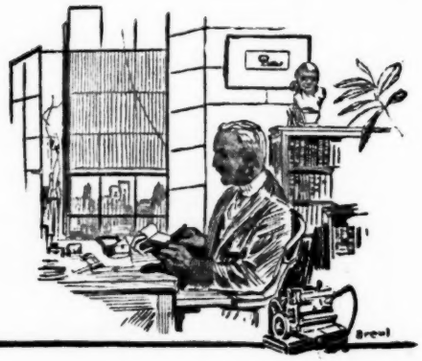
If operators were selected on this basis, many organizations now without talent capable of designing stations would have men who could at least be of value in all conferences relative to the design of the new station.

Interests planning the construction of large stations would do well to select their operator first and let him have part in the choice of the consulting engineers if such are to be retained. The operator should then work with the designers until the designs are completed and thereafter act as an inspector on construction work, supplementing his own efforts in this direction with those of men he has selected to have charge of the various departments of the station, these men to be employed when the installation of equipment in their department begins. Obviously, this assumes that the operator will be an engineer of high caliber, one in fact ranking as well in the profession as any of the designers. HENRY B. JONES.

Lykens, Pa.

A good paint for covering new or old cement floors is made from equal parts of kerosene and cement. Thoroughly mix by slowly sifting the cement into the kerosene and stirring vigorously. After thoroughly mixing, add four parts of coal tar (not oil tar). The resulting paint is impervious to water, oil or acids.

QUESTIONS AND ANSWERS



Actual Cost per Electrical Horsepower per Annum

We have in our plant for the year 1921 a total consumption of 54,190 kilowatt-hours at a cost of $2,373.31. Our maximum demand load would average for the 12 months about 70 horsepower. The Hydro Commission penalizes us 20 per cent in our power factor. What have we paid per electric horsepower per year delivered

W. J. B.

The cost per kilowatt-hour consumed is $2,373.31 divided by 54,190 kw.-hr., giving 4.379c. per kw.-hr. Since an electrical horsepower hour is equal to 1 kw.-hr. times 0.746, it follows that the cost of each electrical horsepower-hour consumed is $4.379 \times 0.746 = 3.266$c. Figuring an electrical horsepower a year as having $365 \times 24 = 8{,}760$ hours, the cost of each unit consumed is $\$0.03266 \times 8{,}760 = \$286.10$ per electrical horsepower-year. If you were penalized 20 per cent for lagging current, then the cost without penalty would be $\$286.10 \div 1.20 = \$238.42$ per horsepower-year.

Slapping Sound in Motor-Driven Ammonia Compressor

In motor-driven ammonia compressors I have frequently noticed a distinct "slap" in the cylinders which sounds very much like water hammer. What is the cause of this? Is it liable to result in injury to the machine or any of its parts? What is the remedy?

A. J. L.

This noise is in all probability due to liquid being drawn over from the evaporating coils. If the compressor suction elbow is frosted over, it may be taken as evidence that the suction gas is saturated, and under such conditions it is by no means unusual to find some liquid entering the compressor. A thermometer placed in the suction will show if the gas temperature corresponds to the saturation pressure. It is usually advisable to have the temperature a few degrees above the saturation temperature corresponding to the suction pressure. In this way the operator is sure that the gas is superheated a trifle and is dry.

Equalizing Cutoff of Corliss Engine

If a Corliss engine cuts off at ¼ stroke at one end and ½ stroke on the other end what would be the cause and remedy?

D. J. D.

Cutoff occurs when the cutoff cam has been placed by the governor in position for releasing the valve from further action by the wristplate, and inequality of cutoff is caused by improper relative adjustment of the lengths of the governor reach rods for operation of the cutoff cams. The cutoff can be equalized by adjusting the length of the governor reach rod to either valve, thereby lengthening the cutoff on one end and relieving as much of the load from the other end. But in equalizing the cutoffs there will be less derangement of the valve gear by shortening the cutoff on one end and lengthening it on the other.

If, by merely adjusting the governor reach rods for a given load, there is a tendency of variation of equality of cutoffs for other loads, that would be due to the difference of obliquity of the reach rods with the governor reach-rod lever and the valve arms.

For equalizing cutoffs, block up the governor halfway and note whether the reach-rod lever stands about at right angles to a line drawn midway between the reach rods. With the valves hooked on, place the piston at ¼ stroke and raise the governor until the valve is tripped by the cutoff cam. Then block the governor to that position and place the engine on ¼ stroke from the other end and see whether cutoff takes place. If not, lengthen or shorten the reach rod so cutoff will not take place and adjust the reach rod so cutoff will just take place. Then block the governor a little lower and test the equality of cutoff of opposite ends. In place of raising the governor until the valves are released, the governor can be blocked in the average running position and the rods may be adjusted to obtain cutoff when the engine is turned over to the same length of stroke from each end; or, generally, the rods can be adjusted to obtain equality of cutoff, guided by indicator diagrams taken when the engine is supplied with steam at the average running pressure and carrying the average load.

Fixed Eccentric and Reversing Throttle

How is reversing an engine accomplished with a single fixed eccentric?

W. L. C.

In an engine provided with an ordinary D slide valve arranged for outside steam admission but without lap or lead and the eccentric just 90 deg. ahead of the crank, the engine would be reversed if the steam supply were to be suddenly interchanged with the exhaust, so that steam may be conveyed from the engine by the steam pipe and conveyed to the engine by the exhaust pipe. However, the design of the valve must be such as to allow of this change, because with inside admission the pressure tends to lift the valves off the seat.

In order to interchange the offices of the steam and exhaust pipes, they must be connected to a controlling valve designed to operate on the same principle as a slide valve. The arrangement using a slide valve for the purpose is illustrated diagrammatically by the figure.

The ends of two pipes *X* and *Y* are connected together

in the chest of the controlling valve V and formed into ports x and y as in the valve seat of a D slide valve steam engine. Between these ports is an exhaust passage P leading directly to the main exhaust pipe. Live steam is brought to the controlling valve chest through the pipe L, and an ordinary slide valve V is placed over the ports. When the valve V is moved downward, the bottom port y and connecting pipe Y leading to the central port of the cylinder C are placed in communication with the main exhaust pipe P, and at the same time the pipe X is in direct communication with live steam in the controlling valve chest through the port x.

With the controlling valve in position for admission of steam through port x and steam pipe X to the steam chest of the main valve D, the engine runs as ordinarily with outside steam admission. But if the controlling

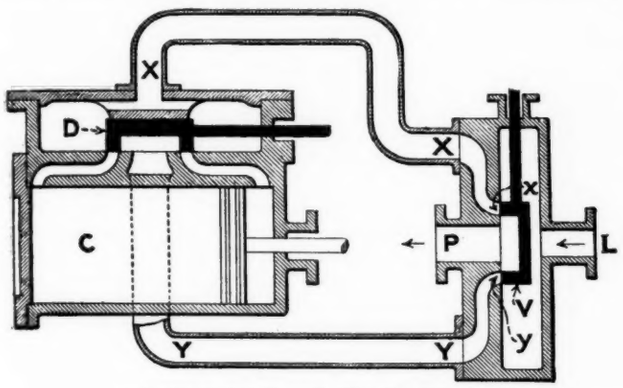


DIAGRAM OF SLIDE VALVE USED AS REVERSING THROTTLE

valve is moved upward, the pipe X is placed in communication with the exhaust port P and at the same time port y is opened for a supply of live steam through the pipe Y to the under side of the main slide valve D.

With steam and exhaust pressures thus changed to opposite sides of the piston, the engine is reversed by simply moving the valve V up or down.

The slide-valve type of controlling valve is employed in some designs of marine steam steering gear in which the controlling valve is operated by movement of the pilot wheel; and different types of balanced valves are used for interchanging the steam and exhaust on engines of steam winches, etc., under the designation of reversing throttle valves.

Preventing Burned Spots on Collector Rings

We have a 150-kw. 164 r.p.m. 480-volt alternating-current generator. One of the collector rings has six burned spots on it close together, which are about the size of the bottom of the brush. Any information as to the cause of this trouble will be appreciated.

T. F. M.

One of the most common causes for burnt spots on collector rings is vibration which makes the brush break contact with the ring, producing a burnt spot on the surface. This condition is especially troublesome if the vibration is of periodic character, breaking the contact of the brush repeatedly at the same spot on the ring. It may result from unequal expansion of the ring destroying its true cylindrical form as the machine warms up. This fault is most likely to occur with spoked rings of light cross-section. In some cases the trouble may be corrected by grinding the ring after it has been heated up to operating temperature. It is well, where possible, to perform this grinding operation at the full running speed of the machine, as at this speed there may be a distortion that does not exist at lower speeds.

Other sources of troublesome vibration are brushes too loose in the holders, insecure mounting of brush-holders, loose bearings, pounding of reciprocating engines and a mechanically unbalanced rotating element. The remedy in all these cases is to correct the mechanical fault. It is wrong, as is sometimes done, to try to overcome mechanical fault by the use of an abrasive brush.

Chattering of the brushes is a form of vibration that is frequently a source of spotting. It may be due to loose brush-holders or too much clearance between the brush and the holder. Chattering may also be due to the use of a brush with too high a coefficient of friction for the peripheral speed of the ring on which it is operated. In this case it is best to select a brush with a lower coefficient of friction.

Where the rotating speed of the ring is very high, as is often the case with turbo-alternators, it is sometimes found advantageous to use a brush of low specific gravity. The lower inertia of such a brush, as compared with that of a brush of high density, enables it to be held in more intimate contact with the ring.

The construction of the brush-holder and the angle at which it is set are points having an important bearing on the tendency of the brush to chatter. Clamp-tight brush-holders should never be used on high-speed rings or commutators, as the inertia of the holder added to that of the brush is likely to cause considerable jumping, even where the inequality of the contact surface is very slight.

Burnt spots on rings sometimes result from hard or soft spots in the material composing the rings. This is a somewhat common fault in cast-iron rings, and spongy spots are of rather frequent occurrence in bronze rings, especially where the composition is high in copper. The best operation of rings of this nature is generally attained by using a brush with some polishing or even a slight abrasive action. This may result in a noticeable wearing of the ring, but if flat spots are avoided by this means, the ultimate ring life will probably be greater than would be the case where frequent turning is necessary to remove the flat spots.

Current left on when the machine is standing is a less common cause of flat spots than those previously mentioned, but one that may sometimes be found even with field rings when the current might not be thought excessive. The temperature attained under such contact on a stationary ring is higher than might be realized at first thought.

Surges of current due to short-circuit, sudden peak loads, hunting between machines operating in parallel, or static disturbances may produce small burnt spots on collector rings which, if not cleaned off, may develop into spots of considerable size. The original cause in such cases may be beyond the control of the operator, so that all he can do is to see that the ring is put in proper condition after the injury has taken place.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Second Revision of the A.S.M.E. Boiler Code

WHEN the first A.S.M.E. Boiler Code was prepared in 1914, arrangements were made to have it revised every four years. After the revision of 1918, the code was reprinted in the revised form. The second revision is now in process, a number of changes having been approved by the Boiler Code Committee. It is the desire of the committee that these revisions be fully and freely discussed so that it may be possible for anyone to suggest changes before the rules are brought to final form and presented to the council for approval. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West Thirty-ninth Street, New York City, in order that they may be presented to the Committee for consideration.

The revisions that have so far been approved by the Boiler Code Committee are printed here in full. These apply to the 1918 revised Code. All added matter appears in small capitals (LIKE THIS) and all deleted matter in italic type (*like this*). The deleted matter is also shown inclosed in brackets.

PAR. 1 REVISED:

Specifications are given in these Rules for the important materials used in the construction of boilers, and where given, the materials shall conform thereto. IF, IN THE DEVELOPMENT OF THE ART OF BOILER CONSTRUCTION, OTHER MATERIALS THAN THOSE HEREIN DESCRIBED BECOME AVAILABLE, SPECIFICATIONS FOR THE SAME MAY BE SUBMITTED FOR CONSIDERATION AND APPROVAL.

PAR. 9 REVISED:

9. Cross pipes connecting the steam and water drums of water-tube boilers, headers, cross boxes and all pressure parts of the boiler proper over 2-in. pipe size, or equivalent cross-sectional area, shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings, when the maximum allowable working pressure exceeds 160 lb. per sq.in. THE USE OF BESSEMER STEEL IS PROHIBITED FOR THE PRESSURE PARTS OF BOILERS. Malleable iron may also be used when the maximum allowable working pressure does not exceed 200 lb. per sq.in., provided the form and size of the internal cross-section perpendicular to the longest dimension of the box, is such that it will fall within a 7-in. by 7-in. rectangle.

PAR. 12 REVISED:

12. Cast iron shall not be used for nozzles or flanges attached directly to the boiler for any pressure or temperature. CAST IRON SHALL NOT BE USED [*nor*] for boiler and superheater mountings such as connecting pipes, fittings, valves and their bonnets, for steam temperatures of over 450 deg. fahr.

PAR. 20 REVISED:

20. The minimum thicknesses of tube sheets for FIRE-TUBE [*horizontal return tubular*] boilers, shall be as follows:

When the diameter of tube sheet is

42 In. or under	Over 42 in to 54 in.	Over 54 in. to 72 in.	Over 72 in.
$\frac{3}{8}$ in.	$\frac{7}{16}$ in.	$\frac{1}{2}$ in.	$\frac{9}{16}$ in.

PAR. 25 REVISED:

25. *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

	Flange	Firebox
Carbon	Plates $\frac{3}{4}$ in. thick and under—NOT OVER [0.12] 0.25 per cent Plates over $\frac{3}{4}$ in. thick—NOT OVER [0.12] 0.30 per cent	
Manganese	0.30-0.60 per cent	0.30-0.50 per cent
Phosphorous	Acid. Not over 0.05 per cent	Not over 0.04 per cent
	Basic. Not over 0.04 per cent	Not over 0.035 per cent
Sulphur	Not over 0.05 per cent	Not over 0.04 per cent

PAR. 29 REVISED:

29. *Modifications in Elongation.* *a.* for material over $\frac{1}{8}$ in. in thickness: From the figure representing the percentage of elongation required as determined in accordance with Par. 28*a*, there shall be deducted an amount equal to four times the difference between the ordered thickness in inches and $\frac{3}{4}$ [$\frac{1}{8}$] in., except that the minimum elongation required shall in no case be less than 20 per cent.

b. For material $\frac{1}{4}$ in. in thickness, the elongation shall be measured on a gage length of 6 in.

PAR. 36 REVISED:

36. *Marking.* *a.* Each shell plate shall be legibly stamped by the manufacturer with the melt or slab number, name of manufacturer, grade and the minimum tensile strength of the stipulated range as specified in Par. 28, in TWO [*three*] places [*two of*], which shall be located NOT LESS THAN [*at diagonal corners about*] 12 in. from the edge [*and one about the center*] of the plate, or at TWO [*a*] points selected and designated by the purchaser so that AT LEAST ONE [*the*] stamp shall be plainly visible when the boiler is completed.

b. Each head shall be legibly stamped by the manufacturer in two places, about 12 in. from the edge, with the melt or slab number, name of manufacturer, grade, and the minimum tensile strength of the stipulated range as specified in Par. 28, in such manner that the stamp is plainly visible when the boiler is completed.

c. Each butt strap shall be legibly stamped by the manufacturer in two places on the center line about 12 in. from the ends with the melt or slab number, name of manufacturer, grade, and the minimum tensile strength of the stipulated range as specified in Par. 28.

d. The melt or slab number shall be legibly stamped on each test specimen.

ADD THE FOLLOWING TO PAR. 36:

e. IT IS PERMISSIBLE TO TRANSFER, WITHOUT IMITATION, THE MARKINGS ON THE PLATE UNDER AUTHORITY OF AN AUTHORIZED INSPECTOR IN CHARGE; SAID INSPECTOR TO PUT HIS PRIVATE MARK AFTER THE TRANSFERRED STAMP.

f. IF, DURING FABRICATION IN THE BOILER SHOP, REMOVAL OF BOTH GROUPS OF THE PLATE MANUFACTURER'S STAMPS CANNOT BE AVOIDED BECAUSE OF THE CUTTING OR PUNCHING OF NECESSARY HOLES IN THE PLATES, ONE GROUP OF SUCH STAMPS MAY BE TRANSFERRED TO A PERMANENT POSITION BY RESTAMPING UNDER THE SUPERVISION OF AN AUTHORIZED STATE, MUNICIPAL OR INSURANCE COMPANY INSPECTOR. WHEN STAMPS ARE TRANSFERRED THE PLATE MANUFACTURER'S NAME SHALL NOT BE IMITATED. THE INSPECTOR SHALL PUT HIS PRIVATE STAMP BESIDE THE TRANSFERRED GROUP AND A RECORD OF THE TRANSFER AND THE INSPECTOR'S STAMP SHALL BE NOTED ON THE DATA SHEET. A GROUP OF STAMPS CONSISTS OF THE MANUFACTURER'S NAME, MANUFACTURER'S TEST IDENTIFICATION NUMBER, GRADE AND TENSILE STRENGTH.

PAR. 48 REVISED:

IV. PERMISSIBLE VARIATIONS IN GAGE

48. The gage of each bar shall not vary more than 0.01 in. from that specified.

PAR. 180. ADD FOLLOWING PARAGRAPH:

THE FACTOR OF SAFETY USED IN DETERMINING THE MAXIMUM ALLOWABLE WORKING PRESSURE CALCULATED ON THE CONDITIONS ACTUALLY OBTAINED IN SERVICE SHALL NOT BE LESS THAN 5.

PAR. 182 REVISED:

182. The distance between the center lines of any two adjacent rows of rivets, or the "back pitch" measured at right angles to the direction of the joint, shall have the following minimum values:

a If $\frac{P}{[D]d}$ is 4 or less, the minimum value shall be $2[D]d$;

b If $\frac{P}{[D]d}$ is over 4, the minimum value shall be:

$$2[D]d + 0.1\ (P - 4[D]d)$$

where

P = pitch of rivets in outer row where a rivet in the inner row comes midway between two rivets in the outer row, in.

P = pitch of rivets in the outer row less pitch of rivets in the inner row where two rivets in the inner row come between two rivets in the outer row, in. (It is here assumed that the joints are of the usual construction where the rivets are symmetrically spaced.)

[D]d = diameter of the rivet holes in.

PAR. 194 REVISED:

194. *Domes.* THE REQUIREMENTS OF PARS. 187 AND 188 SHALL APPLY TO RIVETED LONGITUDINAL JOINTS OF DOMES EXCEPT THAT FOR DOMES 24 IN. AND LESS IN DIAMETER FOR PRESSURES EXCEEDING 100 LB., THE LONGITUDINAL JOINTS MAY BE LAP-RIVETED IF THE FACTOR OF SAFETY IS NOT LESS THAN 8. [*The longitudinal joint of a dome 24 in. or over in diameter shall be of butt and double-strap construction, irrespective of pressure. When the maximum allowable working pressure exceeds 100 lb. per sq.in., the flange of a dome 24 in. or over in diameter shall be double-riveted to the boiler shell.*]

THE FLANGE OF A DOME 24 IN. OR OVER IN DIAMETER SHALL BE DOUBLE-RIVETED TO THE BOILER SHELL. WHERE THE FLANGE OF THE DOME IS USED FOR REINFORCING OR ATTACHING IT TO THE SHELL, THE DIAMETER OF THE DOME SHALL NOT EXCEED ONE-HALF THE DIAMETER OF THE SHELL OR BARREL OF THE BOILER. [*The longitudinal joint of a dome less than 24 in. in diameter may be of the lap type, and its flange may be single-riveted to the boiler shell provided the maximum allowable working pressure on such a dome is computed with a factor of safety of not less than 8.*]

The dome may be located on the barrel or over the firebox on traction, portable or stationary boilers of the locomotive type. [*Up to and including 48 in. barrel diameter. For larger barrel diameters, the dome shall be placed on the barrel.*]

Flanges of domes shall be formed with a corner radius, measured on the inside, of at least twice the thickness of the plate for plates 1 in. thick or less, and at least three times the thickness of the plates for plates over 1 in. in thickness.

PAR. 201 REVISED:

201. *Structural Reinforcements.* When channel irons or other members are securely riveted to the boiler heads for attaching through stays, the transverse stress on such members shall not exceed 12,500 lb. per sq.in. In computing the stress, the section modulus of the member shall be used without addition for the strength of the plate. The spacing of the rivets over the supported surface shall be DETERMINED BY THE FORMULA IN PAR. 199 USING 135 FOR THE VALUE OF C [*in conformity with that specified for staybolts.*]

If the outstanding legs of the two members are fastened together so that they act as one member in resisting the bending action produced by the load on the rivets attaching the members to the head of the boiler, and provided that the spacing of these rivets attaching the members to the head is approximately uniform, the members may be computed as a single beam uniformly loaded and supported at the points where the through braces are attached.

PAR. 205 REVISED:

205. The distance from the edge of a staybolt hole to a straight line tangent to the edges of the rivet holes may be substituted for p for staybolts adjacent to the riveted edges bounding a stayed surface. When the edge of a FLAT stayed plate is flanged AND RIVETED, THE DISTANCE FROM THE CENTER OF THE OUTERMOST STAYS TO THE INSIDE OF THE SUPPORTING FLANGE SHALL NOT EXCEED THE PITCH OF THE STAYS, p, PLUS THE INSIDE RADIUS OF THE FLANGE [*p shall be measured from the inner surface of the flange, at about the line of rivets to the edge of the staybolts or to the projected edge of the staybolts.*]

PAR. 206 REVISED:

206. The MAXIMUM PITCH p AS GIVEN IN PAR. 199 [*distance between the edges of the staybolt holes*] may be INCREASED BY THE STAYBOLT HOLE DIAMETER WHERE [*substituted for p for*] staybolts ARE adjacent to a furnace door or other boiler fitting, tube hole, handhole or other opening.

PAR. 212*c*. REVISED:

c. A FURNACE FOR A VERTICAL FIRE-TUBE BOILER, 38 IN. OR LESS IN OUTSIDE DIAMETER, WHICH REQUIRES STAYING, SHALL HAVE THE FURNACE SHEET SUPPORTED BY ONE ROW OF STAYBOLTS, OR MORE, THE CIRCUMFERENTIAL PITCH NOT TO EXCEED 1.05 TIMES THAT GIVEN BY THE FORMULA IN PAR. 199 AND IN TABLE 4.

THE LONGITUDINAL PITCH BETWEEN THE STAYBOLTS, OR BETWEEN THE NEAREST ROW OF STAYBOLTS AND THE ROW OF RIVETS AT THE JOINTS BETWEEN THE FURNACE SHEET AND THE TUBE SHEET OR THE FURNACE SHEET AND MUD RING, SHALL NOT EXCEED THAT GIVEN BY THE FOLLOWING FORMULA:

$$L = \frac{(220 \times T^2)^2}{(P \times R)}$$

EXCEPT WHEN THIS VALUE IS LESS THAN THE CIRCUMFERENTIAL PITCH, IN WHICH CASE THE LONGITUDINAL PITCH MAY BE AS GREAT AS THE ALLOWABLE CIRCUMFERENTIAL PITCH where

L = LONGITUDINAL PITCH OF STAYBOLTS.
T = THICKNESS OF FURNACE SHEET IN SIXTEENTHS OF AN INCH.
P = MAXIMUM ALLOWABLE WORKING PRESSURE IN LB. PER SQ.IN.
R = OUTSIDE RADIUS OF FURNACE, IN INCHES.

THE STRESS PER SQUARE INCH IN THE STAYBOLTS SHALL NOT EXCEED 7,500 LB. AND SHALL BE DETERMINED IN THE WAY SPECIFIED IN PAR. 212*d*.

PAR. 212*d*. INSERT NEW SECTION AS FOLLOWS:

d. FOR FURNACES OVER 38 IN. IN OUTSIDE DIAMETER OF VERTICAL FIRE-TUBE BOILERS AND OTHER TYPES OF FURNACES AND COMBUSTION CHAMBERS NOT COVERED BY SPECIAL RULES IN THIS CODE, WHICH HAVE CURVED SHEETS SUBJECT TO EXTERNAL PRESSURE, THAT IS, PRESSURE ON THE CONVEX SIDE, THE STAYING, BOTH CIRCUMFERENTIAL AND LONGITUDINAL, SHALL BE PROVIDED FOR IN ACCORDANCE WITH THE FOLLOWING FORMULA:

$$P = \frac{CT^2}{p^2} + 250\,\frac{T}{R}$$

WHERE p AND THE VALUE OF C ARE AS GIVEN IN PAR. 199, p SHALL NOT EXCEED 2T, AND p^2 SHALL NOT EXCEED 0.008CTR.

THE STRESS PER SQ.IN. IN STAYBOLTS SHALL NOT EXCEED 7,500 LB., BASED ON A TOTAL STRESS OBTAINED BY MULTIPLYING THE PRODUCT OF THE CIRCUMFERENTIAL AND LONGITUDINAL PITCHES BY

$$(P - 250\,\frac{T}{R}).$$

PAR. 216 REVISED:

Stays shall be used in the tube sheets of a fire-tube boiler if the distance between the edges of the tube holes exceeds the maximum pitch of staybolts for the corresponding plate thickness and pressure given in Table 4. That part of the tube sheet which comes between the tubes and the shell need not be stayed, if the GREATEST distance [*to the nearest tangent common to two tube holes when*] measured ALONG A RADIAL LINE FROM THE INNER SURFACE OF THE SHELL TO THE CENTER POINT OF THE TANGENT COMMON TO ANY TWO TUBE HOLES ON THE SHELL SIDE OF SUCH [*between the*] holes does not exceed 1.25 TIMES THE [*this*] maximum pitch OF STAYBOLTS FOR THE CORRESPONDING PLATE THICKNESS AND PRESSURE GIVEN IN TABLE 4 [*by more than 3 in.*]. The tube holes to which a common tangent may be drawn in applying this rule shall not be at a greater distance from edge to edge than the maximum pitch referred to.

PAR. 217 REVISED:

217. The net area to be stayed in a segment of a head may be determined by the following formula:

$$\frac{4(H - d - 2)^2}{3}\sqrt{\frac{2(R - d)}{(H - d - 2)}} - 0.608 = \text{area to be}$$

stayed, sq.in. where

H = distance from tubes to shell, in.
d = distance DETERMINED [*given*] by formula in Par. 214.
R = radius of boiler head, in.

PAR. 231 REVISED:

Maximum allowable working pressure on truncated cones.

a. Upper combustion chambers of vertical submerged tubular boilers made in the shape of a frustum of a cone

when not over 38 in. in diameter at the large end, may be used without stays if computed by the rule for plain cylindrical furnaces (Par. 239) making D in the formula equal to the diameter at the large end; provided that the longitudinal joint conforms to the requirements of Par. 239.

b. When over 38 in. in diameter at the large end, that portion which is over 30 in. in diameter shall be [*fully*] supported by staybolts or gussets. IF SUPPORTED BY STAY BOLTS PAR. 212*d* SHALL APPLY. IF SUPPORTED BY GUSSETS THE SPACING OF THE RIVETS ATTACHING THE GUSSETS TO THE COMBUSTION CHAMBER SHALL NOT EXCEED THE STAYBOLT SPACING GIVEN BY PAR. 212*d* [*to conform to the provisions for staying flat surfaces. In this case*] the top row of staybolts shall be at a point where the cone top is 30 in. or less in diameter.

[*In calculating the pressure permissible on the unstayed portion of the cone, the vertical distance between the horizontal planes passing through the centers of the rivets at the cone top, and through the center of the top row of staybolts shall be used as L in Par. 239, and D in that paragraph shall be the inside diameter at the center of the top row of staybolts.*]

PAR. 239 (ENTIRE PARAGRAPH CHANGED TO READ AS FOLLOWS:)

PLAIN CIRCULAR FURNACES. The following rules apply in general to unstayed circular furnaces:

a-1 The longitudinal joint may be riveted or lap welded by the forging process, or the furnace may be of seamless construction.

a-2 The longitudinal joint if riveted shall have an efficiency greater than

$$\frac{P \times D}{1{,}250 \times T}$$

a-3 The walls shall not be less than $\frac{7}{16}$ in. thick.

a-4 Butt strap seams shall be used only where they are protected from contact with the fire.

a-5 The furnace may be of any length or height.

The following rules apply specifically to unstayed circular furnaces of different diameters:

A. 12 in. to 18 in. outside diameter, inclusive.

b-1 A riveted longitudinal joint may be of the lap type.

b-2 The maximum allowable working pressure for furnaces not more than four and a half diameters in length or height shall be determined by formulas *a* and *b* as follows:

a. Where the length does not exceed 120 times the thickness of the plate

$$P = \frac{51.5}{D}\left((18.75 \times T) - (1.03 \times L)\right)$$

b. Where the length exceeds 120 times the thickness of the plate

$$P = \frac{4{,}250 \times T^2}{L \times D}$$

where

P = maximum allowable working pressure, lb. per sq.in.
D = outside diameter of furnace, in.
L = total length of furnace between centers of head rivet seams (not length of a section), in.
T = thickness of furnace walls, in sixteenths of an inch.

b-3 The maximum allowable working pressure for furnaces over four and one-half diameters in length or height shall be determined in accordance with Par. 241.

B. Over 18 in. outside diameter to and including 30 in. inside diameter.

c-1 A riveted longitudinal joint may be of the lap type.

c-2 The maximum allowable working pressure shall be determined by formulas *a* and *b* of Par. 239; if over six diameters in length or height, *L* in the formula shall be taken as six times the diameter.

C. Over 30 in. inside diameter to and including 36 in. inside diameter.

d-1 A riveted longitudinal joint may be of the lap type provided the furnace does not exceed 36 in. in length or height.

d-2 If the length of a horizontal furnace exceeds 36 in. and the joint is riveted, a butt and single or double strap construction shall be used.

d-3 The maximum allowable working pressure shall be determined by formulas *a* and *b* in A; if over six diameters in length, *L* in the formula shall be taken as six times the diameter.

D. Over 36 in. inside diameter to and including 36 in. outside diameter.

e-1 When riveted the longitudinal joint shall be butt and single or double strap construction.

e-2 The maximum allowable working pressure shall be determined by formulas *a* and *b* in A; if over six diameters in length *L* in the formula shall be taken as six times the diameter.

[Further proposed revisions, starting with Par. 243, will appear in an early issue.—Editor].

British Engineers Discuss Economical Steam Production

In a recent meeting of the Engineering Section of the British Association for the Advancement of Science considerable attention was given to the subject of economical steam production. While this meeting, as reported in *Engineering* (London), dealt in the main with marine practice there was much of general interest.

The first paper, "Home-Produced Oil Fuel," by C. H. Lander, dealt particularly with the British situation with regard to fuel oil, and was intended to be a semi-official expression of the views of the Fuel Research Board. Dr. Lander said that on account of the large navy and merchant marine, the question of fuel oil was a vital one in Great Britain. Since there were no oil wells, considerable attention was being given to the commercial possibilities of the shale-oil fields in Scotland and other parts of Great Britain. The report stated that it was improbable that the Scottish shale-oil output would be increased by an amount that would have any appreciable bearing on the problem, while the large shale deposits in other parts of Great Britain suffered from an excess of sulphur, which not only affected the amount of oil distilled, but rendered very difficult the production of a marketable oil.

It followed that the main source of British-produced oil must be found in coal. On the basis of good practice, for every 1,000,000 tons of oil produced, 16,000,000 tons of coal would have to be carbonized, so that profitable outlets would have to be found for about 11,000,000 tons of coke and 56,000,000 cu.ft. of rich hydrocarbon gas. These figures, he said, showed that the production of fuel oil from coal by low-temperature carbonization on any adequate scale involved a revolutionary change in the preparation and use of fuel. Even if the more immediate technical and economic problems of low-temperature carbonization were successfully solved, the wider economic and financial elements involved in the establishment of a new industry on an enormous scale would have to be faced.

Should a low-temperature process of carbonization prove a feasible operation commercially, its first application would probably be to the 35,000,000 tons of coal used for domestic purposes. This would produce about 2,000,000 tons of fuel oil, or considerably more than the peace requirements of the Navy, leaving a quantity which would go far to replenish the tanks of oil-driven steamers when in a home port. The paper called attention to the importance of distilling the coal at a low temperature, in order to get the maximum recovery of oil. As to the quality of the coal oil in reference to its suitability for steam raising and for use in internal-combustion engines, Dr. Lander stated that it had a specific gravity around 1.05 at 60 deg. F., and was thin and fluid at this temperature. The solidifying point was about 23 deg. F.

The crude oil as produced contained a large proportion of emulsified oil and watery vapor which had to be removed by passing through a filter press, and then allowed to settle at a suitable temperature. This brought the water content down to about 1 per cent. giving an excellent fuel oil with a calorific value ranging from 16,000 to 16,500 B.t.u. per

pound. However, the oil as produced flashed at ordinary temperatures, so that it was advisable to distill off some of the lighter fractions before using it. He called attention to recent experiments made in Germany that promised to open up great possibilities for the production of fuel oil from heavy oils and tars, and bituminous coal.

The next paper, by Engineer-Commander Fraser Shaw, of the British Navy, dealt with the economic steam production with special reference to marine practice. In discussing the possibilities of various fuels for marine use, Commander Shaw stated that fuel oil, powdered coal and gas had the common advantage that efficient combustion could be maintained by watching the color of the flame and the products of combustion. However, fuel oil was the only one of these three that had so far gained a footing in marine work. Powdered coal was being carefully considered, while gas seemed to be impracticable on account of the weight, size and complication of the gas producers required. The general adoption of oil fuel on ships of the Navy and Merchant Marine had resulted, he said, in a marked increase in economy.

Commander Shaw characterized as truly insane the practice of having the boiler room a dark and dismal hole, so that only low-grade men would work in it. "Stoking," he said, "is a skilled profession," and if properly instructed men were employed in the merchant service, the saving in coal would run into thousands of tons every month.

In the discussion that followed the papers, C. E. Stromeyer, of the Manchester Steam Users' Association, deplored the tendency to over-rate the efficiencies obtained with new fuels and new methods of burning them. In computing the advantages of forced draft, account should be taken, he said, of the loss due to the extra power required to create the high draft with fan engines of low efficiency. This, of course, would not apply to motor-driven fans.

Prof. G. G. Stoney remarked that high temperatures and pressures had caused considerable trouble in steam turbines. He stated that cast iron should not be used at temperatures higher than 450 deg. F. Differences in temperature between one part of a turbine and another caused even greater difficulties than high temperatures. He claimed that in a modern land installation using turbines supplied with steam at 350 lb. per sq.in. and 750 deg. F., exhausting into a condenser at 80 deg. F., the temperature range of 670 deg., would give considerable trouble if used in a single cylinder. He stated that troubles due to high temperatures could be relieved by compounding or by the use of an impulse wheel at the high-pressure end.

Hydro-Electric Power Development in California*

By George R. Martin†

While the expenditure during 1922 of seventy million dollars for hydro-electric construction in California makes a new record, the state is only upon the threshold of its comprehensive development era. For the next ten years appropriations of one hundred million dollars a year will be required to carry on the surveyed and charted programs of the power companies. The fact that this year an army of 8,000 men is working upon electric development construction, and that during the next twelve years its ranks will probably be increased to 10,000 men, shows conclusively that California is awake to the importance of quickly developing her natural resources and setting them to produce wealth and prosperity.

Dollar for dollar, day's work for day's work, the hydro-electric development of California, now well under way, is the greatest construction undertaking in the annals of the Western Hemisphere. Based on present estimates of the commercial value of hydro-electric power, as compared with the cost of producing power from fuel, its complete development is placed at about 1935. The new investment up to that date will aggregate one billion dollars, or almost three times the construction cost of the Panama Canal. There has already been developed in the state 1,500,000 hp. Developments in 1922 and 1923 will aggregate about 300,000 hp., or 20 per cent in addition to all that has been developed, and this peak has barely kept abreast of the demand.

In 1921 California's two largest hydro-electric companies, the Southern California Edison Co. and the Pacific Gas & Electric Co., were among the first five power companies in America in size, as measured by electric production for that year. Of the development work now in progress and planned for 1923, about 67 per cent is in the hands of these two companies. The other hydro-electric companies, namely, the California-Oregon Power Co. the Great Western Power Co., the Western States Gas & Electric Co., the San Joaquin Light & Power Co. and the Southern Sierras Power Co., are also engaged in development work, and have plans for speeding up their activities to conform to the demands of the power market. The City of Los Angeles has additional hydro-electric developments planned, and San Francisco is proceeding with its Hetch Hetchy development. Steam power, pending the complete development of water-power resources, is a necessary auxiliary and is being installed by the Los Angeles Gas & Electric Co. and the San Diego Gas & Electric Company.

Big Creek-San Joaquin Program of Southern California Edison Company

Unprecedented in magnitude, both from an engineering and an electrical viewpoint, is the program of the Southern California Edison Co. on its Big Creek-San Joaquin River project in the High Sierras of northeastern Fresno County. Of a chain of mountain lakes now being deepened by impounding dams, Huntington Lake, impounded in 1914 at an altitude of 7,200 ft., was the first. Florence Lake, over the crest of the 10,000-ft. summit of the Kaiser range, will be the next, the work on its dam having just been started. Shaver Lake, now a natural sheet of water, will be more than doubled in surface and capacity, and later on Vermillion Lake, far up on the west fork of the San Joaquin River, will be increased in size by an impounding structure.

From Huntington Lake the water is delivered to the first power house through a fall of 2,170 ft.; from the first to the second through a drop of 1,900 ft., and then farther down the canyon of the San Joaquin River to a third power house. In a few weeks work will be started on the fourth of this string of power houses, which will generate 100,000 hp. This will come into service next summer and will be the largest hydro-electric power plant west of Niagara Falls. Its ultimate capacity will be two or three times that of the original installation. Below this fourth development is the site of the fifth power house, which will use the same water 6,000 ft. below the first station. Four or five more power stations are to be built before the full million and a quarter potential horsepower of the Big Creek-San Joaquin project is completely developed, some ten or twelve years hence. Florence Lake tunnel, fourteen miles long, is attracting the attention of the engineering world because it is the longest tunnel ever projected on this continent. It was started in December, 1920, and will be finished in March, 1925, making a world's speed record for drilling through solid granite. In this entire project, eighty-six miles of tunnel will be bored through solid rock.

Pit River Development of Pacific Gas and Electric Company

Quite different from the Edison High Sierras project is the Pacific Gas and Electric Co.'s big development on the Pit River. This river is the most easily controlled power stream in the state; it is rated at more than 600,000 potential horsepower. The unique feature is that its constant and almost even flow of about 2,500 sec.-ft. is over twice the precipitation in its apparent drainage area. This is accounted for by subterranean sources, which reach through lava beds as far as Idaho. The first big development, known as Pit River Number One, has a capacity of 94,000 hp. at an effective head of 450 ft. This plant has just been put into operation and is doubtless the most

*Abstract of a paper read before the eleventh annual convention of the Investment Bankers Association at Del Monte, Calif., Oct. 10.

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beautiful example of power-house construction in the West. It is the first of a chain of five power houses which will be built as the electric demands of San Francisco and the Bay cities require, at points ranging sixty miles down stream and terminating at Pit River, Big Bend, where a generating plant of 256,000 hp. will complete the project. According to present estimates the construction program will be finished about 1932.

In the southern part of the state, a 220,000-volt transmission line is being built by the Southern California Edison Co. to bring the current generated at its High Sierras power plant to the San Joaquin Valley and Southern California communities and to Los Angeles, where it is now supplying about 60 per cent of the electricity consumed in the southern metropolis. In the north, 200 miles of this new high-voltage type transmission line is being built by the Pacific Gas & Electric Co., to convey the product of the Pit River power plants to San Francisco and the Bay cities, and to supply the increasing electrical demands of the fertile upper state counties.

Higher Steam Pressures or Pulverized Coal?*

BY FREDERICK A. SCHEFFLER

Two years ago, when the Edison Association of Illuminating Companies held its Annual Meeting at New London, Conn., the technical section developed a discussion as to what should be done with a view to lowering the cost of producing a kilowatt-hour, which was at that time over 100 per cent greater than before the World War.

Various suggestions were made by engineers and others present, one statement being that the boiler pressure should be increased to 400 or 500 lb. Another official and engineer of a large public-service corporation in the East quite emphatically made the statement that the only way to reduce these costs, in his opinion, would be to use pulverized coal, and he predicted that in two years time this practice would begin to be generally used.

The writer, in discussing this subject, predicted that the excessive cost of the high-pressure idea would prevent a realization of lower costs, on account of the additional capital or fixed charges absorbing any gain that would be made from better thermal efficiency of the plant, and also said that rough figures would show that the desired results would be more likely to be obtained if only a portion of the additional expense involved was used in equipping the plant to use pulverized coal.

This question of higher pressures and temperatures is still a mooted one and is quite thoroughly discussed in a most excellent manner in a paper presented by Col. C. F. Hirshfield, Chief Research Department, of the Detroit Edison Co., before the Cleveland Section of the A.S.M.E. in March, 1921. In this paper the author states that it is "his personal opinion that 700 deg. F. is about as high as we can safely go at present" and suggests a working pressure of steam at 400 lb.

As it is quite evident that there must be some point where the capital costs and fixed charges accompanying same will prohibit the reduction of the present kw.-hr. cost from being benefited thereby, the author has made a study of the question from an investment and operating standpoint, comparing the present average practice as to pressures and temperatures with the above suggested 400 lb. pressure and 700 deg. final temperature. The basis on which the following estimates are made is as follows:

Capacity of plant, 100,000 kw.; consisting of four 25,000-kw. units and twelve 1,600-hp. boiler units (19,200 rated boiler h.p.) or approximately 5 kw. per boiler h.p.

As we are primarily interested more particularly in the *difference* in cost between the present average practice and the higher pressures, we have made a study of the various items entering into the costs of both suggestions, consulting with prominent manufacturers in order to obtain this information, which may be considered authentic and reasonable. For the lower pressures and temperatures we have adopted 250 lb. and 600 deg. F. temperature. For the higher, as previously stated, 400 lb. and 700 deg. F. The items that are affected by the increase of pressure and the additional expense involved, due to the difference in pressure and temperature, are as follows:

ADDITIONAL COST OF USING 400 LB. SQ.IN., 700 DEG. F.

(a)	Difference in cost of boilers and superheaters 19,200 hp. at $13 per hp., or 2.49 per kw., including freight and erecting charges	$249,600
(b)	Difference in economizers 4 $per hp. or $0.768 per kw	76,800
(c)	Difference in steam turbines 100,000 kw. at $2 per kw	200,000
(d)	Difference in steam piping, forged valves and pipe covering at $2 per kw	200,000
(e)	Difference in feed pumps and auxiliary apparatus 50c. per kw	50,000
	Estimated total difference in cost	$776,400

The average water rate of the turbines at 250 lb. pressure is assumed to be 10¾ lb. per kw.-hr. and at 400 lb.

COMPARING COSTS OF MEDIUM- AND HIGH-PRESSURE PLANTS, BOTH PULVERIZED-COAL AND STOKER-FIRED

Item	—250 Lb. Press. Plant— Col. 1 Stoker Fired	Col. 2 Pulv. Coal Fired	—400 Lb. Press. Plant— Col. 3 Stoker Fired	Col. 4 Pulv. Coal Fired
(1) Lb. coal per kw.-hr.	1.36	1.25	1.31	1.214
(2) B.t.u. per kw.-hr.	17,680	16,250	17,030	15,782
(3) Thermal eff. of plant, per cent	19.31	21.20	20.22	21.75
(4) Evap. per lb. coal from and at 212 deg. F.	10.43	11.27	10.43	11.27
(5) Fuel, tons per hr.	24.40	22.36	23.42	21.23
(6) Fuel cost per hr.	$122.00	$111.80	$117.10	$106.15
(7) Fuel cost per day	$2,928.00	$2,683.00	$2,810.40	$2,547.60
(8) Repairs ($1.50 per rated hp. per year) per day	78.80		78.80	
(9) Power for operating stokers, air supply, coal handling 4 per cent	117.00	204.00	117.00	198.22
(10) Fixed charges 12 per cent per year on $422,400, incl. coal bunkers and conveying and ash handling, stokers and air supply	138.00	141.00	138.00	141.00
(11) Ash removal 48 tons at 25 cents	12.00	4.00	12.00	4.00
(12) Total cost per day, Items 7, 8, 9, 10 and 11	A-$3,273.80	B-$3,032.20	C-$3,156.20	D-$2,890.82
Additional fixed chgs. at 12 per cent. (See below)—per day			250.60	250.60
Additional maintenance charges (See below) per day			21.25	21.25
Actual total daily costs Col. 3 and 4			C′ 3,428.05	D′ 3, 62.67

Pulv., drying, repairs, labor, power, conveying and air supply 34c. ton*

Fixed chgs. pulv. coal plant, conveying system, bunkers, coal-burning equipment, air supply ash handling. Cost, $476,000, inc. $60,000 for bldg.

4 tons day average

* These costs are based on pulverizing thousands of tons of bituminous coal and are, consequently, accurate. The items are as follows: Per net ton

Repairs—complete system	8 cents per ton
Power for all operation at ¾ cents kw.-hr. (17 kw.-hr.)	12¾ cents per ton
Drying	6¼ cents per ton
Labor	7 cents per ton
Total	34 cents per ton

In the operation of the plant we have adopted an annual load factor of 40 per cent and a fair average bituminous coal has been assumed in both cases of 13,000 B.t.u., and 8 per cent of ash and the combined boiler furnace and economizer efficiency with stokers at 78 per cent, and with pulverized coal an equivalent efficiency of 85 per cent. The following costs have been used: Cost of coal delivered, $5 per long ton; cost of power, ¾ cent per kw.-hr.; cost of common labor, 40c. an hour. In the operating costs we have omitted taking into consideration the firing-room labor, as these items would be practically identical in either case.

With the foregoing items fixed, the steam requirements per hour for the 250-lb. pressure plant will be 451,500 lb., which translated into steam per hour from and at 212 deg.

*Presented at the annual convention of the A.I.E.E., Niagara Falls, Ont., June 26-30, 1922.

is equivalent to 569,793 lb. For the 400-lb. pressure plant these figures are 420,000 lb. and 547,260 lb. respectively.

Additional data may be determined from the accompanying table.

The cost of operation per diem in Col. 3, letter *C*, $3,156.20, is not entirely complete, as to this cost should be added the additional fixed charges due to the cost of the 400-lb. pressure plant as compared with the 250-lb. pressure plant, which, as previously shown, will be $776,400. The per diem interest charges on this amount at 12 per cent equals $250.60.

Furthermore, there will be additional maintenance costs, due to the higher pressures and superheat, which may be taken as 1 per cent. The per diem cost of this item will be $21.25. These two daily costs added to item *C* is $3,156.20 + 250.60 + 21.25 equal *C'*, $3,428.05. This is, consequently, the total daily operating and fixed charges cost of the plant, so far as it refers to the furnace equipment, for the 400-lb. pressure plant.

Comparing this with the daily operating costs of the 250-lb. pressure plant fired with pulverized coal, Col. 2, Item 12, *B*—$3,032.20, it will be noted there is a difference of $395.85 which constitutes the saving which would be effected by the use of pulverized coal and this is equal to $144,485 per year.

These figures demonstrate therefore, that under the same operating conditions the high-pressure cost of operation as compared with pulverized coal on the low-pressure plant will be over $144,000 more per year and the thermal efficiency of the plant will be better with pulverized coal (17,030—16,250) by 780 B.t.u. per kw.-hr., or reduced to percentage of B.t.u. in the coal utilized, the difference is nearly 1 per cent (21.20—20.26).

The estimate shows that the pulverized-coal plant and necessary storage and burning equipment, auxiliaries and distributing system, etc., can be built in a substantial manner for approximately $476,000 (at prices prevailing December, 1921), of which $60,000 is allowed for a separate building (42x144 ft.) for the milling and drying plant, having a capacity of 750 to 800 net tons of pulverized coal per day. This cost is only slightly more than the complete stoker equipment with distributing system, auxiliaries, etc., installed. The costs of these equipments would be the same for both the 250-lb. and 400-lb. pressure plants.

The question might be raised as to the basis on which these estimates have been made in regard to thermal, boiler and furnace efficiencies. The author believes he is quite safe in stating that at the present time there is no plant in this country at any rate, operating on a B.t.u. basis of 17,680, stoker fired, as shown in Col. 1 of the tables, although plans have been laid down for one or two power houses not yet in operation to give these results, so that this figure would indicate the best possible practice that can be obtained under the assumed load factor and other conditions of a plant of this size and pressure.

On the other hand, actual performance of boilers fired with pulverized coal in power-plant service indicates that there is no difficulty in operating under these load conditions at the 85 per cent efficiency we have used for the basis of our calculations, which, as shown in Col. 2, is equivalent to 16,250 B.t.u. per kw.-hr. or 1¼ lb. of coal, containing 13,000 B.t.u.

The final conclusions are:

1. It will cost a great deal less money to equip and use pulverized coal in power plants in order to obtain the highest efficiency and the lowest operating costs than it would to use high pressure of 400 lb. and high superheat of 700 deg. final.

2. That lower B.t.u. per kw.-hr. and higher over-all thermal efficiency will be obtained by substituting pulverized coal firing in lieu of any other known method using the moderate high pressure and superheat in common practice today, compared with higher pressures and temperatures.

3. That the benefits accruing from the net difference in station water rate between the present practice as to pressure and temperatures and the higher pressures and temperatures are comparatively small and do not warrant the excessive additional first cost and yearly fixed charges for the higher pressures and superheat.

4. That the cost per short ton of coal handled and burned by stokers in the 250-lb. pressure plant (exclusive of the cost of the coal) will be 52c. and with pulverized coal 58c. For the 400-lb. pressure plant this cost would be increased to 95c. per ton with stokers, which increase is due principally to the additional fixed charges over the 250-lb. pressure plant.

A. E. S. C. and Bureau of Standards Consider Power Safety Codes

Of 106 projects now before the American Engineering Standards Committee, twenty are concerned with mechanical engineering and fifteen are electrical. Twenty-four standards or safety codes have been approved and thirty-six are up for approval. The remaining forty-six represent codes and standards that are either in the process of formulation or that are now being considered by committees appointed by the various industrial technical and governmental bodies interested in each particular subject. In this way more than 200 such bodies are officially participating in the work of the A.E.S.C. through their accredited representatives. A regular interchange of information is maintained by the committee with the national standardizing bodies of the leading foreign nations.

The code for electricity meters submitted by the National Electric Light Association and the Association of Edison Illuminating Companies has been unanimously approved as the "American Standard." Among the other projects still under consideration, the following will be of particular interest to *Power* readers: safety codes for mechanical refrigeration, power-transmission apparatus, electric-power control and compressed-air machinery; pipe flanges and fittings; shafting; ball bearings, and a code for the rating of electrical machinery.

The United States Bureau of Standards likewise has been concerning itself with standardization in the power field. A member of the Bureau's staff is chairman of a committee of the American Bureau of Welding that is to conduct a series of tests on tanks to obtain information for the preparation of safety codes and especially for the use of the Boiler Code Committee of the A.S.M.E. The Bureau is also co-operating in the revision of the National Electrical Code, published by the National Board of Fire Underwriters.

Electrification of the State of Victoria, Australia, by the utilization of Morwell brown coal is being rapidly carried forward by the State Electricity Commission, according to reports received by the Department of Commerce. The main power house, which is to be situated at the new township of Yallourn, about five miles from Morwell, and which is expected to be in operation in about two years, will have an initial capacity of 50,000 kw. All the principal contracts for the plant and machinery for the main power station at Yallourn are being placed, and reports indicate good progress. Specifications, contract conditions and tender forms are being received in this country for the information of American firms desiring to bid on contracts for material going into the Morwell project. Such forms, covering strain and pin type insulators, one 1,500-kw. low pressure turbo-alternator, with accessories, water-tube boilers with accessory plant, and steel work for building and electrically operated coal-handling plant are now available to interested American companies, who may obtain copies from the New York and Chicago district offices of the Bureau of Foreign and Domestic Commerce or from the Commissioner for Australia in the United States, 61 Broadway, New York.

Further advances in the generation of extremely high electric potentials have been made in the high voltage engineering laboratory of the General Electric Co. at Pittsfield. The record voltage of 1,500,000 volts was obtained by connecting one terminal with 1,000,000 volts above ground and the other with 500,000 volts below ground. With single-phase connections, 1,250,000 volts was produced, and with three-phase and neutral grounded 1,000,000 volts.

News in the Field of Power

Power Show To Stress Need for Fuel Economy

The list of manufacturers who have reserved space at the National Exposition of Power and Mechanical Engineering, to be held in New York City from December 7 to 13, shows that all phases of the problem of economical power generation and use will be given thorough treatment. Each of the exhibitors will emphasize in his display the power-saving possibilities of his products. There will thus be given to designing and operating engineers and manufacturing executives the opportunity to gain a great deal of information in a short time, as the wares of the various exhibitors in similar lines may be compared and personal contact established with the supplying organizations.

In addition to an impressive array of prime movers, there will be exhibits of stokers, pulverized-fuel apparatus, coal-handling equipment, firebrick, water purifiers, feed-water heaters, economizers, superheaters, blowers, valves, piping, pipe covering, steam separators, pumps—in fact, all of the devices entering into modern power plant practice.

The personnel of the advisory committee in charge of the Exposition was announced in the April 11 issue of *Power*. The Exposition will immediately follow the annual meetings of the A.S.M.E. and A.S.R.E., and the members of these societies will be admitted upon presentation of their membership cards. The programs of these meetings have been developed in co-operation with the Exposition, and it is expected that the exhibits will, in many cases, elaborate the information presented at the technical sessions.

Demands for More Power Are Being Met

Four more large central-station companies have authorized the erection of new plants or additions to present equipment, to meet the increasing demands for power in the East and Middle West:

The West Penn Power Co. will almost triple the capacity of its Springdale plant by adding two new 35,000-kw. turbo-generators, according to a statement by A. M. Lynn, president of the company.

At Grand Tower, Ill., on the Mississippi River just below St. Louis, the Middle West Utilities Co. is erecting a new power station, whose initial equipment will be one 20,000-kw. Westinghouse turbo-generator. The operating conditions will be 350 lb. steam pressure at the turbine, 200 deg. F. superheat, and 29-in. vacuum.

The Edison Electric Illuminating Co. of Boston has authorized the construction of a new plant at Weymouth, of 300,000 kw. ultimate capacity. Stone & Webster will design the plant in collaboration with I. E. Moultrop, of the Edison company. Two 30,000-kw. turbines will probably form the initial installation.

Another new plant will be erected in the southwestern part of Detroit, the Public Lighting Commission having instructed Smith, Hinchman & Grylls, of that city, to prepare plans and specifications for a plant of 150,000 kva. ultimate capacity, of which four units of 25,000 kva. each will be initially installed.

President Harding Appoints Coal Commission

President Harding announced on Oct. 10 the personnel of the Fact-Finding Coal Commission, which is to study the problems developed by the recent coal strikes and to make recommendations to Congress regarding legislation to prevent recurrent labor troubles in the coal fields. The seven men appointed are:

John Hays Hammond, engineer.

George Otis Smith, director of the United States Geological Survey, regarded as an authority on the economic and labor troubles connected with the coal industry.

Thomas Riley Marshall, former Vice-President of the United States.

Judge Samuel Alschuler, of Chicago, a United States Circuit Judge who has acted as an arbitrator in recent labor disputes.

Clark Howell, editor of the Atlanta *Constitution*.

Dr. Edward T. Devine, of New York, a writer on social and economic questions.

Charles P. Neill, of Illinois, former Commissioner of Labor.

Mr. Hammond, the single engineer member of the Commission, has long been associated with important mining and financial interests, in this country as well as in South Africa.

New Hydro-electric Plant in Maine

The immediate construction of a 625-kw. hydro-electric station on the Great Works River at South Berwick, Me., has been authorized by the Berwick & Salmon Falls Electric Co., a subsidiary of the Twin States Co. The plant is expected to be in operation by Jan. 1, 1923.

The annual output of the station will be about 1,400,000 kw.-hr. The project includes a 185-ft. dam, 28 ft. high, over which will be erected a 200-ft. highway bridge. Reinforced concrete will be used throughout. The cost of the power project has been set at $130,000.

New Ohio Plant Will Use Steam At 550 Lb.

The Ohio Power Co., a subsidiary of the American Gas & Electric Co., is preparing plans for a new power station to be erected on the Muskingum River at Philo, Ohio, about nine miles south of Zanesville, and contract has been placed for two 35,000-kw. G. E. turbines which will be operated at 530 lb. steam pressure and a total temperature of 725 deg. F. at the turbine throttle. Contract has also been placed with the Babcock & Wilcox Co. for the boilers, which will be built for 650 lb. working pressure, although they will be operated at 550 lb. The boiler units will consist of boilers, superheaters and economizers of the same design as those being installed at the Waukegan station of the Public Service Co. of Northern Illinois, described in the Sept. 12 issue. It is understood that many new features will be embodied in the design of this station. Sargent & Lundy, Chicago, are the consulting engineers.

Edison Companies' Convention Shows Optimism

That hydro-electric and steam power construction is now proceeding on an unprecedented scale was emphasized at the convention of the Association of Edison Illuminating Companies at White Sulphur Springs, W. Va., Oct. 10-13. The readiness with which funds may be obtained for new enterprises is creating a spirit of optimism throughout the electrical industry, and engineering and operating staffs are preparing to handle economically and efficiently large increases in load.

One of the most interesting reports was that of the committee on steam turbines and generators, which treated of several important advances in steam turbine design and of the evolution of auxiliary systems and heat balance in power plants.

In the address of the president, M. S. Sloan, reference was made to the need for greater water-power development and wider interconnection of generating systems in order to secure a cheaper and more dependable power supply. By making the bonds of public utilities a legal investment for savings banks and their customers, the president said, a much needed widening of the public utility security market could be obtained.

For future extensions of Edison systems, alternating current is being seriously considered, according to W. C. L. Eglin, of Philadelphia, who recommended the universal use of the four-wire, three-phase, star-connected system for all phases of generation, transmission and distribution. In contrast to this recommendation, there was a paper by C. W. Wilder and C. H. Shaw, of New York City, advocating direct-

current, low-tension distribution and evidencing a desire to perfect this method by citing the New York Edison Company's method of equalizing feeder loads, which has made possible a ten per cent increase in load. This has permitted the operation of several substations on two buses instead of three.

Omaha To Use A.S.M.E. Boiler Code

The City of Omaha, Nebraska, is the latest to fall in line by adopting the provisions of the A.S.M.E. boiler code in its new building code, which includes rules covering boilers, tanks, retorts, vulcanizers and vessels used for cooking under pressure, having a capacity of 50 gallons or over.

According to the new code, no permit will be issued for the installation of any boiler, after the passage of the ordinance, which was not in the city at the time of the code's adoption, unless it is constructed in accordance with the requirements of the A.S.M.E. code. Any boiler within the city at the time the ordinance was passed can change owners or locations only after a thorough inspection, before the boiler is coated with paint or any other preservative. Other provisions of the building code relate to the number of manholes in boilers of different types and sizes.

Sixteen States Adopt Reciprocal Registration of Engineers

Rules for the reciprocal registration of professional engineers, permitting an engineer registered in one state to practice in other states having license laws, were agreed upon in a conference of the Council of State Boards of Engineering Examiners at the Congress Hotel, Chicago, on Oct. 2 and 3.

The operation of such a reciprocal arrangement calls for uniformity in the state license laws, and to bring about this condition a resolution was passed by the conference requesting each state board to have its laws changed wherever necessary.

According to the rules drawn up by the Council, to be eligible for reciprocal registration an applicant must already have been licensed in a member-state of the Council. He must submit a detailed professional record, showing that he has had ten years' experience in professional engineering, beginning not earlier than his eighteenth year, and showing in addition that he is qualified to design as well as to direct engineering operations. Professional experience is considered to begin only when the candidate has reached a position in engineering work requiring original thought and responsibility. The Council considered graduation from an engineering school of recognized standing to be equivalent to four years of professional engineering practice.

The sixteen states taking part in the agreement are Arizona, Colorado, Florida, Indiana, Illinois, Iowa, Louisiana, Michigan, Minnesota, New Jersey, North Carolina, Oregon, South Dakota, South Carolina, West Virginia and Wyoming.

Reciprocal registration with Canada and Mexico was provided for by the appointment of an investigating committee. At present, engineers going into Canada cannot practice unless registered in that country. Mexico has given notice that American engineers will not be allowed to practice there without equal recognition in this country for her engineers.

Next year the council will again meet in Chicago, on the first Monday in October. The officers elected for the ensuing year are: John T. Cox, Ann Arbor, Mich., president; O. Laurgaard, Portland, Ore., vice-president; P. H. Daggett, Chapel Hill, N. C., secretary-treasurer.

Coming Conventions

Society of Industrial Engineers, 29 West 39th St., New York City. National convention, New York City, Oct. 18-20.

National Association of Practical Refrigerating Engineers; Edward H. Fox, secretary, 5707 West Lake St., Chicago, Ill. Annual convention and exhibition at St. Louis, Mo., Nov. 1-4.

Society of Naval Architects and Marine Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

American Society of Mechanical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 4-8.

American Society of Refrigerating Engineers; W. H. Ross, secretary, 154 Nassau St., New York City. Annual meeting at New York City, Dec. 4-6.

National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City, Dec. 7-13.

Power Commission Is Speeding Up Its Work

The staff of the Federal Power Commission is engaged in an active endeavor to hurry action on all pending applications. Of the 349 applications filed with the Commission, 201 have been acted on—64 preliminary permits and 64 licenses have been issued, 25 applications have been rejected and 48 applications have been withdrawn or cancelled. Of the remaining 148, there are 35 applications on which action has been suspended indefinitely because the Commission must await the action of some other agency. In this category are the St. Lawrence and Colorado River applications and those on the Columbia River which affect the Columbia basin project in the State of Washington.

Of the remaining 113 applications, thirty are so incomplete that the Commission cannot act on them. When the water-power act was passed a flood of applications was received before rules could be drawn or forms prepared. So as not to work an injustice or to cause unnecessary delay in prospective developments, the Commission accepted any informal application or declaration of intention. A large number of these applicants were not prepared to undertake immediate development. When applications now are received, it is the policy of the Commission either to require the applicant to proceed actively with his undertaking or else to throw out the application. The purpose is to save the Commission the burden of correspondence, investigation and public hearings which can have no immediate result.

Water-Power Projects

The Pacific Power and Light Co., of Portland, Ore., has been granted a preliminary permit covering a proposed project on the Deschutes River at the reclamation site, twenty miles above the mouth of the river. H. S. McGowan, of McGowan, Wash., also was an applicant for this site, but his application was denied on the ground that the Pacific Power and Light Co. is in a much better position to develop the project and to use the power in its general distribution system.

The Columbia Valley Power Co., has received a preliminary permit covering two sites on the Deschutes River. The company applied for a permit to cover five sites, but the Federal Power Commission, at a meeting on Oct. 10, stated that the company should demonstrate what it can do with the two upper sites before the permit is extended to include the other three. One of the two sites can be developed without large outlay of capital and can be operated as an entering wedge with which to begin to build up a load before attempting the larger development. A conflicting application by H. S. McGowan was rejected.

The preliminary permit of **James B. Girand** covering a development on the Colorado River was extended by the commission until March 19, 1923. Mr. Girand's permit was granted July 19, 1921, and was to expire July 19 of this year. It was extended until Oct. 19. These extensions have been necessary because of objection on the part of the Reclamation Service. As a result of the work being done by the Colorado River Commission, it is hoped that a comprehensive policy will be developed for the use of the water in the Colorado River. By extending the permit until March 19, it is believed that sufficient time has been allowed during which the report of the commission will become available.

Preliminary permits to **Ed. Fletcher**, of San Diego, were authorized, covering a 3,600-hp. development on Santa Isabel Creek in the Cleveland National Forest and a 900-hp. development on Boulder Creek in the same forest.

Personals

Milo Smith Ketchum, formerly director of the civil engineering department of the University of Pennsylvania, is now dean of the Engineering College and director of the Engineering Ex-

periment Station, University of Illinois.

Charles L. Edgar, president of the Edison Electric Illuminating Co., Boston, was tendered a luncheon on Sept. 29 in honor of his thirty-five years of service with the organization.

George R. Sterling, formerly president and manager of the Economic Engineering Co., Lyndhurst, N. J., is now the proprietor of the George R. Sterling Boiler and Engine Works, at Rochester, N. Y.

Guy L. Bayley, in charge of the mechanical and electrical departments of the Panama-Pacific International Exposition in 1915 and for many years engaged in hydro-electric work on the Pacific Coast, has joined the staff of Sanderson & Porter, consulting engineers, of New York, Chicago and San Francisco. Mr. Bayley, who is a Californian by birth and education, has been employed by the Pacific Gas & Electric Co., the Sierra & San Francisco Power Co., and the Universal Electric & Gas Co., as an operator of hydro-electric systems. In 1916 he erected the hydro-electric plant in Yosemite Valley for the Department of the Interior, and in his new position he will be engaged largely in water-power development.

New Publications

Engines and Boilers. By Thomas T. Eyre, dean College of Engineering, State University of New Mexico. Published by The Macmillan Co., New York City. Cloth; 5½ x 8½ in.; 234 pages; 170 figures. Price, $3.50 net.

This book is written for college students taking their first course on steam engines and boilers. The matter is covered in a simple and direct way and does not assume that the reader has ever seen the inside of a power plant. This plan, while excellently adopted to the needs of elementary students, is of less value to the operating man, because he would already be very familiar with much of what he would read. However, there are points here and there where the knowledge of the operating man may be a little sketchy. This is particularly likely to be true with such subjects as valve diagrams, flow of steam on turbine blades, etc. The treatment of these subjects may be found helpful.

Liquid Fuel. By William H. Booth, Second Edition. Published by E. P. Dutton & Co., New York City. Cloth; 6 x 9 in.; 297 pages; 85 illustrations; 29 tables. Price, $4.

This volume contains much of the information contained in the author's more elaborate work on "Liquid Fuel and Its Combustion" issued in 1903, together with some more recent data on the burning of petroleum fuel. The author deals in the main with English stationary and marine practice. He ignores the more advanced methods of burning oil as followed in America. This is most unfortunate, as the largest consumer of boiler oil is the United States, and it is here that there is the greatest need of a thoroughly practical treatise on the subject as applying to American conditions. If the engineer wishes to obtain a general idea of the production of crude oil, its chemical constitution and efficiency and the precautions to be followed in burning oil, this volume will be found most suitable.

Society Affairs

New Haven Branch, A.S.M.E., will meet on Oct. 23 to consider "Some National Aspects of the Labor Problem."

Mid-Continent Section, A.S.M.E., will hold its management meeting on Oct. 26 instead of on Oct. 28, as announced in last week's issue.

Philadelphia Section, A.S.M.E., will meet on Oct. 24 at 8 p. m., at the Hotel Adelphia, for its annual smoker, get-together, carnival and vaudeville show.

Cleveland Section, A.S.M.E., will meet on Oct. 24 at the Hotel Winton at 8 p. m. to hear a paper on machine shop practice by A. L. De Leeuw, consulting engineer.

San Francisco Section, A.S.M.E., will hold its management meeting on Oct. 20, at the Engineers' Club at 7.30 p.m. John A. Button, vice-president and general manager, Pacific Gas & Electric Co., will be the principal speaker.

Phillipsburg Association No. 10, N.A.S.E., has been presented with a glass model of the return-tubular boiler made by the Keeler Boiler Co., Williamsport, as the prize for correctly answering the questionnaire sent out by the Keeler Company to the associations throughout the United States last winter on the subject of the theoretical circulation of water in a return-tabular boiler. Nearly fifty local associations took part in the contest. The judges were Arthur L. Rice, editor of *Power Plant Engineering*, John W. Lane, editor of *National Engineer*, and Fred R. Low, editor of *Power*.

Business Items

The National Tube Co. has ordered six 19,600 sq.ft. Bigelow-Hornsby boilers for burning blast-furnace gas, to be installed at the company's Lorrain Works.

The Brown Hoisting Machinery Co., Cleveland, Ohio, has placed its conveyor sales in charge of E. P. Sawhill, who has had nearly thirty years of engineering and selling experience with this type of equipment.

The Sinclair Pipe Line Co. has placed several orders for Diesel engines to replace steam pumping units for oil pipe lines. The Nordberg Manufacturing Co. was awarded a contract for six 750-hp. and six 440-hp. units; the Busch-Sulzer Co. received an order for six 750-hp. and six smaller units, and McIntosh & Seymour received an order for eight 400-hp. Diesels.

Trade Catalogs

Underfeed Stokers—Detroit Stoker Co., Detroit, Mich. Bulletin No. 230, describing the Detroit single-retort underfeed stoker.

Boilers—Geo. T. Ladd Co., Pittsburgh, Pa. Bulletin No. 21, a supplementary description of the large Ladd water-tube boilers at the River Rouge plant of the Ford Motor Co.

CO_2 and Draft Recorders—Jos. W. Hays Corp., Michigan City, Ind. A folder entitled "O.K.'d by all Industries" which presents reports from a few representative users of Hays Automatic CO_2 and Draft Recorders, with an insert dealing with the operation of the instrument and the use of the chart.

Low-Head Hydraulic Turbine Runner—Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Bulletin No. 1640-B, a reprint of a paper presented at the December, 1919, annual meeting of the A.S.M.E., giving the theory and test results of the company's new type of high-speed low-head runner.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 2, 1922	Oct. 9, 1922
Pool 1,	New York	$5.25-5.75	$4.75-5.75
Smokeless,	Columbus	5.00-6.50	5.50-6.00
Clearfield,	Boston	4.25-4.75	4.00-4.50
Somerset,	Boston	4.25-5.00	4.00-4.60
Kanawha,	Columbus	5.75-6.00	4.00-5.35
Hocking,	Columbus	4.50-5.25	3.25-3.75
Pittsburgh No. 8	Cleveland	4.50-5.25	4.25-4.50
Franklin, Ill.,	Chicago	4.50-5.00	4.25-4.75
Central, Ill.,	Chicago	4.35-4.75	3.25-4.00
Ind. 4th Vein,	Chicago	4.65-5.00	4.50-4.75
West Ky.,	Louisville	3.75-4.00	3.50-3.75
Big Seam,	Birmingham	2.60-2.90	2.60
S. E. Ky.,	Louisville	5.00-5.75	4.00-5.50

FUEL OIL

New York—Oct. 11, Port Arthur light oil, 22@25 deg. Baumé, 5c. per gal.; 30@35 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

Chicago — Oct. 7, for 24@26 deg. Baumé, $1.20 per bbl.; 32@36 deg., 3½c. per gal. in tank car, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Sept. 12, f.o.b. refinery, Pennsylvania, 36@40 deg., 6¼c.; Kentucky fuel oil, 26@30 deg., 4½c. per gal.; Gas oil, 32@34 deg., 2¾c. per gal.; 36@38 deg., 3c.; 38@40 deg., 3¼c.; Western, 24@30 deg., $1.30 per bbl.

Philadelphia — Oct. 9, 26@28 deg. Baumé, Oklahoma, $1.10@$1.15 per bbl.; 30@34 deg., Oklahoma (group 3). 3@3¼c. per gal.; 16@20 deg. Seaboard, $1.40@$1.50 per bbl.

St. Louis—Oct. 3, for 26@30 deg., 7@7½c. per gal.; 38@42 deg., 8½c., f.o.b. Oklahoma fields in tank cars, rate to St. Louis, 75c. per bbl.; 26@30 deg., $1.12½ per bbl.

Cincinnati—Oct. 10, for 26@28 deg., Baumé, 5½c. per gal.; 28@30, Diesel, 5¼c.; 38@40 deg., distillate, 6c. per gal.

Cleveland—Oct. 10, for 26@28 deg., Baumé, 4¼c. per gal.

Condensed-Clipping Index of Equipment

For quick reading and convenient filing. These products have not been described before in "Power."

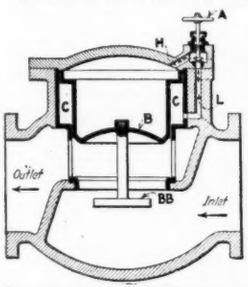
Blocks, Air Cooled Furnace "Power," 1922

Waite & Davey Co., Inc., 9 Jackson Ave., Long Island City, N. Y.

An air-cooled refractory furnace block that leaves numerous air passageways through the bridge and side walls of a furnace so that the temperature of the brickwork may be kept below the fusing point, thus reducing maintenance trouble and expense. Air is circulated through practically hollow furnace walls, and is then returned under the grate, so as to recover the heat absorbed. The blocks are recommended for hand-, stoker-, and oil-fired furnaces, especially the last. Circulation of air through the blocks may be obtained by either forced or natural draft. Described further in "Power" for July 25, 1922, page 136.

Valve, Cushion Check "Power," 1922

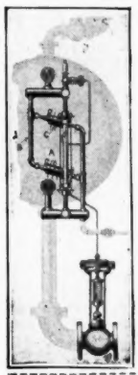
Golden-Anderson Co., Pittsburgh, Pa.



A double cushioning check valve designed to prevent without sudden shock the reversal of flow in pipe lines. It is shown in the open position. If the flow reverses, the valve spool *B* is drawn to its seat by the action of the current upon the piston *BB*. Before the valve can close, however, the liquid in the space *C*, which has its principal outlet through the passageway *L*, passes the valve *A* into the upper chamber. The resulting cushioning effect prevents water hammer. A similar effect is produced in opening; the liquid then has to pass through the passageway *M*, past the valve *A* and back into the space *C*. By adjusting the valve *A*, the opening and closing may be made as slow or as rapid as desired. The valve is made in sizes up to 30 in. and is especially designed for use in discharge lines of pumps and for hydraulic-elevator service. Described further in "Power" for June 6, 1922, page 893.

Valve, Drainage Control "Power," 1922

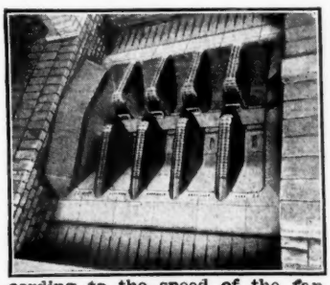
"SC" Regulator Manufacturing Co., Fostoria, Ohio



An apparatus for controlling the drainage of condensation from a central receiver, designed along the same lines as the "SC" boiler feedwater regulator. Water is let out of the receiver through the valve shown at the bottom, which is opened by the spring above it and closed by hydraulic pressure on the diaphragm above the spring. A small pipe connects the diaphragm with the cylinder *A*, which is really a water-jacket around the pipe *B*. The water level in the latter is the same as in the receiver itself, and when it falls far enough to reach the right-hand end of the cylinder *A*, the steam in the pipe *B* raises the temperature of the surrounding water inside the cylinder *A*. This water has no outlet except to the diaphragm, and so presses against the latter and closes the valve. When the level rises inside *B*, the surrounding water cools and allows the valve to open. The second cylinder *C*, just above *A*, works in the same way, except that the water pressure operates a valve that admits steam to a whistle in case the water level rises too high. Described further in "Power" for Aug. 8, 1922, page 207.

Stoker, Lateral Retort "Power," 1922

Underfeed Stoker Co. of America, Book Bldg., Detroit, Mich.



A new stoker consisting essentially of two regular Jones multiple-retort stokers arranged back-to-back so as to form a main retort between them, from the front wall to the bridge wall, with lateral retorts branching off at right angles. Many features are practically the same as in the standard A.C. type; the side cleaning arrangement is used, the underfeed principle is maintained throughout, and a Cole automatic valve is provided to vary the speed of the main and auxiliary pushers according to the speed of the fan engine. Described further in "Power" for Aug. 1, 1922, page 168.

For a permanent file of new and improved power-plant equipment, clip and paste on 3 x 5-in. cards. (Patented Aug. 20, 1918.)

New Plant Construction

PROPOSED WORK

Ariz., Phoenix—The Southwest Portland Cement Co., 356 South Spring St., Los Angeles, is having plans prepared for a cement plant, here. Estimated cost $1,500,000. O. J. Binford, Genl. Mgr. Private plans. Equipment detail not reported.

Ark., Crossett—The Crossett Lumber Co. is in the market for mechanical and generating equipment for proposed power house.

Calif., Knights Landing (Grafton P. O.)—The Meek Estate, c/o F. H. Tibbetts, Engr., Alaska Commercial Bldg., San Francisco, had plans prepared for the construction of a pumping plant including two 16 in. vertical centrifugal pumps, two 75 hp. motors, at Reclamation Dist. 730. Estimated cost $40,000.

Calif., Oakland—The Scottish Rite Bodies, A. & A. S. R., have had preliminary plans prepared for the construction of a cathedral on 14th and Alice Sts. Estimated cost $1,000,000. C. Werner, Humboldt Bank Bldg., San Francisco, Archts.

Calif., Sacramento—The State Dept. Pub. Wks., Div. of Architecture, received bids for equipment for the State Capitol Buildings as follows: complete mechanical equipment, from Latourette-Fical Co., 907 Front St., $90,000, Scott-Lyman & Stack, 421 J St., $139,612, Gould & Johns, 436 East Maple St., Stockton, $161,000; heating, Latourette-Fical Co., $23,733, Scott Co., 381 11th St., Oakland, $28,887, Hateley & Hateley, Mitau Bldg., $34,696; ventilating, McLaughlin Sheet Metal Works, 221 J St., $9,400; electrical, Butte Elec. & Mfg. Co., 534 Folsom St., San Francisco, $25,750. Noted Sept. 5.

D. C., Wash.—H. Wardman, 1430 K St., is having plans prepared for an apartment building, containing 230 apartments, on 13th and I Sts. Estimated cost $1,100,000. Wardman & Waggaman, Archts. Equipment detail not reported. Noted Mar. 7.

Fla., New Smyrna—The Volusia Cypress Co., plans to build a saw mill, planing mill, lumber plant and power house. Estimated cost $100,000. Prices wanted on machinery and equipment.

Ga., Atlanta—The city purchasing agent will receive bids until Oct. 31 for building, delivering and erecting 15 and 30 M.G.D. steam turbine driven centrifugal pumps and 15 M.G.D. cross compound pumping engines complete with all accessories at the Hemphill and the Chattahoochee River pumping stations.

Ga., Savannah—The Western Paper Makers Chemical Co., River Rd., plans to build a paper mill here. Estimated cost $500,000. Architect not announced. Prices wanted on machinery and equipment.

Ill., Astoria—The city council passed an ordinance for water supply system including 30,000 gal. impounding reservoir, 200,000 gal. per day rapid sand filter plant, pump house, 4 motor driven centrifugal pumping units, two, 200 gal. motor driven centrifugal pumps to pump water from lake, one 350 gal. pump for filtered water, one 200 gal. pump for wash water. Estimated cost $40,000. W. A. Fuller, 1917 Railway Exchange, St. Louis, Mo., Engr.

Ill., Chicago—The Bd. Educ., 646 South Clark St., is having plans prepared for a high school on Wilson and Kimball Aves., also addition to high school at Morgan Park, including steam heating systems. Estimated costs $3,000,000 and $1,000,000 respectively. J. C. Christensen, 646 South Clark St., Archt.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams St., has authorized plans for the third section of the Calumet generating station, to consist of two 130,000 kw. units, also the construction of a new plant on the west side, which will eventually contain eight 35,000 kw. units, 2 of which will form the initial installation.

Ill., Chicago—H. Kusel, 35 South Dearborn St., is receiving bids for a 3 story, 200 x 260 ft. theatre, store and office building, including steam heating system, on Belmont St. and Lincoln Ave. Estimated cost $1,750,000. W. W. Ahlschlager, 65 East Huron St., Archt.

Ind., Indianapolis—The Bd. of Sanitary Comrs., J. A. Craven, Pres., City Hall, will receive bids until Oct. 31, for the construction of Sect. 3, Div. 3 and furnishing and erecting mechanical equipment for the Sewage Disposal plant, (1) activated sludge plant, (2) power plant auxiliary equipment including boiler settings and breeching, coal storage bunker, coal handling equipment, power plant piping, boiler feed pumps and regulators, feed water heaters and softening system.

Ia., Fort Dodge—T. G. Warden, Wahkonsa Hotel, is having plans prepared and will receive bids in November for the construction of an 8 story, 100 x 140 x 150 ft. apartment and store building including a steam heating system. Estimated cost $800,000. Damon, O'Meara & Hills, 1123 Merchants Bank Bldg., St. Paul, Archts.

La., Rayville—The city plans to issue $150,000 bonds for an electric light plant.

Me., Portland—Supt. of Lighthouses will receive bids until Oct. 20 for furnishing 2 oil engine compressor units for operating fog signal.

Md., Salisbury — Salisbury Ice Co., J. Price, Pres., is in the market for machin-

ery and equipment for 6,000 ton ice handling plant.

Mich., Holland—The Holland Hospital Assn. have plans prepared and will vote $250,000 bonds Nov. 7 for a 4 story, 40 x 125 ft. hospital including a 75 x 40 ft. boiler room. Robinson & Campau, 715 Michigan Trust Bldg., Grand Rapids, Archts.

Minn., Morris—The city, F. J. Haight, Mgr., will receive bids until Oct. 20 for the construction of a pumping station for water works and also installation of crane. C. F. Tweed, 531 Metropolitan Bank Bldg., Minneapolis, Engr.

Miss., Corinth—The city received bids and awarded contracts in part, for electric light station and distribution as follows: Sect. 2 brick chimney to J. Custodius, Healey Bldg., Atlanta, Ga., Sect. 3, two 300 hp. water tube boilers to Corinth Machine Co., $16,200, Sects. 4, 5, 6 and 7 turbo generator set, exciters and switchboard to Westinghouse Electric Co., $33,200, Sect. 10, steam pipe work to Urbauer-Atwood Heating Co., 1446 South 2nd St., St. Louis, Mo., $7,200. Sect. 1, brick house including foundations for machinery, estimated cost $12,000, all bids rejected; Sects. 8 and 9, bids rejected, purchased distribution system from the Alcorn Light & Power Co., for $20,000, plan to spend $6,000 to $8,000 in improvements. Noted Sept. 19.

Miss., Corinth—The city will soon receive bids for a water distribution system, including two 400 gal. centrifugal pumps, one 750 gal. centrifugal motor driven pump, one deep well pump, also 13 fire hydrants. Estimated cost $35,000. A. H. Beard, 616 Title Guaranty Bldg., St. Louis, Mo., Engr.

Mo., Kansas City—C. P. Shipley, 1627 Genesee St., is in the market for air compressor or duplex power pump, for oil burner in machine shop.

N. Mex., Mountainair—The borough, c/o Mayor, plans to build a municipal electric light plant and also a water works plant. Cost will exceed $25,000.

N. Y., Albany—The Dept. of Pub. Wks., C. L. Cadle, Supt., Capitol, will receive bids until Nov. 1 for the construction of a power house and work incidental thereto, at Vischer Ferry dam, under Contract B-3.

N. Y., Brooklyn—The Brooklyn Edison Co., 360 Pearl St., will receive bids until Oct. 18 for a 12 story office building. Estimated cost $1,000,000. McKenzie Voorhies & Gwelin, 342 Madison Ave., New York, Archts. and Engrs. Equipment detail not reported. Noted Aug. 8.

N. Y., Freeport—The Bd. Educ., will soon receive bids for a high school, including steam heating system, on Pine St. Estimated cost $600,000. W. Adams, 15 West 38th St., New York, Archt. and Engr. Noted Apr. 11.

N. Y., New York—T. A. Meyer, Archt. and Engr., 150 East 42nd St., is preparing plans for a 14 story, 80 x 85 ft. apartment building, including steam heating system, at 174 West 86th St. Estimated cost $750,000. Owner's name withheld.

N. Y., New York—The New York Edison Co., 130 East 15th St., will soon receive bids for a 3 story, 44 x 123 ft. power house at 10 Stone St. Estimated cost $150,000. W. Whitehill, 709 6th Ave., Archt. E. M. Van Norden, 130 East 15th St., Engr.

N. Y Rochester—The Seneca Operating Co. is receiving bids for the construction of a 15 story, 43 x 95 ft. hotel on South Clinton St. Estimated cost $420,000. Esenwein & Johnson, 781 Ellicott Sq., Buffalo, Archts. Equipment detail not reported.

N. Y., Tupper Lake—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until Nov. 15 for boiler plant equipment and distribution system, also refrigerating equipment. Spec. 4719 and 4720.

N. C., Burlington—The Burlington Hotel Co., R. L. Holt, Pres., plans to build a hotel. Estimated cost $250,000 to $700,000. Architect not selected.

Ohio, Akron—J. E. Eberson, Archt., 64 East Van Buren St., Cleveland, is receiving new bids for a 10 story, 132 x 190 ft. hotel and theatre on East Market St., for the Akron Prospect Co., Commodore Perry Hotel, Akron. Estimated cost $2,500,000. Equipment detail not reported.

Ohio, Chillicothe — The Quartermaster General's Office, 2313 Munitions Bldg., Wash., D. C., will receive bids until Nov. 14 for the construction of a U. S. Veteran's Hospital, here. Estimated cost $1,000,000 to $2,000,000. Noted Sept. 19.

Ohio, Cincinnati—The Union Savings Bank & Trust Co., Union Trust Bldg., had sketches prepared for a 10 story, 100 x 200 x 130 ft. office building on Court and Main Sts. Estimated cost $500,000. Rendigs, Panger & Martin, 609 Lincoln Inn Court, Archts. and Engrs.

Ohio, Cleveland — The Garden Court Realty Co., c/o G. H. Grieble, Archt., 517 Sloan Bldg., has had plans prepared for the construction of ten 3 story, 45 x 60 ft. apartment buildings, including steam heating system, on Euclid Ave. and East 77th St. Estimated cost $400,000.

Ohio, Cleveland Heights (Warrensville P. O.)—F. N. Riley, 1508 Williamson Bldg., Cleveland, is having sketches prepared for 6 and 12 story apartment building on Cedar Rd. Estimated cost $750,000. J. M. Dyer, Ulmer Bldg., Cleveland, Archt. Equipment detail not reported.

Ohio, Dayton—St. Marys Female Educational Institute, Cincinnati, has purchased a tract of 13 acres and plans to build at least 5 buildings, including school and college. Architect not selected.

Ohio, Marion—The Citizens Building & Loan Co., plans to build an 8 story, 61 x 132 ft. bank and office building. Estimated cost $500,000. W. E. Russ, Meridan Life Bldg., Indianapolis, Engr. Equipment detail not reported.

Ohio, Sebring—The Crescent China Co. is in the market for machinery and equipment, including jigger shop, coal loading plant, kilns and boiler house, for new plant for the manufacture of china ware.

Ohio, Steubenville—The Pennsylvania-Ohio Power & Light Co., 2521 East Boardman St., plans to build a steam electric plant here, to furnish power and light as far north as Warren and Youngstown. Estimated cost $15,000,000.

Ohio, Zanesville—The American Gas & Electric Co., Newark, plans to build a steam power and light station here. Estimated cost $20,000,000.

Okla., Tulsa—The National Refining Co. is in the market for machinery and equipment for the two proposed electrical pumping plants, in connection with the extension of its pipe line to Coffeyville, Kan.

Okla., Tyrone—The Town Board, L. F. Stewart, Clk., will soon receive bids for a complete waterworks system, including power house. Estimated cost $70,000. H. Knatt, City Engr.

Pa., Charleroi—The Electric Alloy Steel Co. is in the market for one 500 hp. variable speed motor, 230 volts, field control 105 to 240 r.p.m., one 800 hp. variable speed motor, 230 volts, field control 534 to 793 r.p.m., one 500 kw., 22,000 volt, 60 cycle, 3 phase, M. G. sets and two 500 kw., 22,000 volt, 60 cycle, 3 phase rotaries.

Pa., Johnstown — The Clarion River Power Co. plans to build a large hydro-electric power plant on the Clarion River, above here. Estimated cost $3,000,000. F. T. Hepburn, Pres.

S. D., Rapid City—The State Regents of Educ., will receive bids until Oct. 26 for a boiler house, chimney, one 200 hp. water tube boiler, breeching, piping, etc., for the State School of Mines, C. C. O'Harra, Pres.

Tex., Coleman—The City Comn., E. P. Scarborough, Mayor, will receive bids until Oct. 18 for a dam with main extensions to waterworks, including pump house, pumps, spillway, 23,000 ft. 10 in. c.i. pipe, etc. Elrod Engr. Co., 3202 Elm St., Dallas, Engrs.

Tex., Deweyville—The Peavy-Moore Lumber Co. plans to rebuild its saw and lumber mill, which was recently destroyed by fire, and is also in the market for power house equipment. Estimated cost $200,000.

Va., City Point—The Wilson-Hock Co. is in the market for a 30 to 45 kw. belt driven electric generator, motor generator set and a 50 hp. motor.

Va., Norfolk—The city, C. E. Ashburner, Mgr., will receive bids until Oct. 18, for the construction of grain drier, dust house, boiler house, smoke stack, belt conveyors, elevator leg and other appliances for drying and cooling grain, in connection with grain elevator at the Municipal Terminals.

Va., Radford—The city, P. Murphy, Mgr., is in the market for electrical equipment for new municipal light plant, here.

W. Va., Clarksburg—The Clarksburg Ice & Storage Co. plans to build a 1 story, 50 x 120 ft. ice plant. Estimated cost $50,000.

Wis., Manitowoc—The Oslo Power Co., c/o A. O. Anderson, Mgr., 826 8th St., is receiving bids on a water wheel generator and switchboard for plant at Oslo.

CONTRACTS AWARDED

Ala., Florence—The U. S. Engineers Office, War Dept., awarded the contract for 1,000 hp. turbine with generator, draft tubes, etc., to the S. Morgan Smith Co., York, Pa., $17,060. Noted Aug. 29.

Calif., San Francisco — The Whitcomb Estate, Whitcomb Hotel, has awarded contract for a 7 story addition to hotel on Market St., to Macdonald & Kahn, 130 Montgomery St., $275,000. Additional equipment not reported.

Conn., West Hartford—The town, D. I. Miller, Mgr., awarded the contract for a 2 story, 200 x 210 ft. junior high school on South Main St., to the Johnson-Wester Co., 167 Washington St., Hartford, $429,162. Steam heating system will be installed.

Ill., Chicago—The Pullman Co., 101st St. and Corliss Ave., awarded the contract for the construction of a 1 story, 200 x 250 ft. foundry addition to electrical department, to Sumner-Sollitt Co., 225 North Michigan Ave. Estimated cost $600,000. Equipment detail not reported.

Ill., Jerseyville—J. Heller awarded the contract for complete water distribution system, development of 2 springs and a 100,000 gal. capacity reservoir, 26 x 36 ft. pump house, including two 300 gal. triplex oil driven pumps, one 225 gal. motor driven triplex pump and 1 motor driven Fire Underwriters centrifugal pump, to C. M. Hanes, $215,740.

Mass., Springfield—The Springfield Gas Light Co., West State St., awarded the contract for a power house on Page Blvd., to E. F. Carlson, 244 Main St., $18,000.

Mass., Weymouth—The Edison Electric Illuminating Co., 70 State St., Boston, awarded the contract for construction of a 60,000 kw. power house, here, to Stone & Webster, 120 Bway., New York. Estimated cost $1,000,000.

Mich., Detroit—The Tuller Hotel Co., Park and Adams Aves., awarded the contract for the construction of a 14 story hotel to the Van Blarcom Co., Plymouth Bldg., Cleveland, Ohio. Estimated cost $1,000,000. Equipment detail not reported.

Minn., Duluth—The Andray Hotel Co., c/o Quigley & Doran, Hibbing, awarded the contract for the construction of a 12 story, 100 x 140 ft. hotel, on 1st St. and 4th Ave., W., here, to Jacobson Bros., 619 Columbia Bldg. Estimated cost $1,500,000. Steam heating system will be installed.

N. Y., New Rochelle—The New Rochelle Hospital, Guion Place, awarded the contract for the construction of a hospital to G. Watson, 230 Huguenot St. Estimated cost $250,000. Steam heating system will be installed.

N. Y., New York—The Dept. of Health, 505 Pearl St., awarded the contract for altering and erecting a coal handling plant at Riverside Hospital, North Brother Island, Boro. of Bronx, to the McHarg-Barton Co., 1328 Bway., $16,800. Noted Sept. 26.

Ohio, Canton — The First Natl. Bank awarded the contract for a 14 story bank and office building on Market and Tuscarawas Sts., to Walbridge-Aldinger Co., 2356 Penobscot Bldg., Detroit, Mich. Estimated cost $750,000. Address N. D. Schworm Bldg., Mgr., for equipment detail. Noted Aug. 15.

Ohio, Cleveland — The Bd. Educ., East 6th St. and Rockwell Ave., awarded the contract for installing steam heating plant, including 2 boilers, stokers and blowers at the Collinwood high school to Feldman Brothers, 10305 Barrett Ave., $235,585.

Pa., Phila.—The Logan Ice Co., 10th and Windrim Sts., awarded the contract for a 1 story, 96 x 182 ft. ice manufacturing plant, consisting of 4 buildings, to Monaghan & Losse, 3016 Chestnut St. Noted Sept. 5.

R. I., Pawtucket—J. & P. Coats, Inc., 366 Pine St., awarded the contract for two 3 story, 95 x 370 ft. and 95 x 270 ft. additions to thread mill, to the J. W. Bishop Co., 109 Foster St., Worcester, Mass. Estimated cost $400,000. Steam heating and ventilating systems will be installed. Noted Oct. 3.

Utah, Salt Lake City—The Continental Bank & Bank of the Republic, Consolidated, awarded the contract for a 20 story bank and office building on Main and 2nd Sts., to the P. J. Walker Co., Monadnock Bldg., San Francisco. $1,250,000. Equipment detail not reported. Noted July 4.

Wis., Brillion—The Calumet Canning Co., J. E. De Master, Pres., 623 End Court, Sheboygan, will build by day labor, a 2 story, 50 x 100 ft. canning factory and power house. Estimated cost $45,000. Will require one 40-50 hp. motor and several small motors.

Wis., South Milwaukee—Burnham Bros. Brick Co., 68 Wisconsin St., Milwaukee, awarded the contract for a 1 story, 85 x 100 ft. dryer building for manufacturing plant on Chicago Rd., to Meredith Bros. Co., 1043 Kinnickinnie Ave., Milwaukee. Power house, machine building and brick burning building will be erected later.